Energy Efficient Smart Labs: Lessons from the Leaders

5/16/17
9:30-10:45
Panelists

- Monica Witt, Los Alamos National Laboratory
- Shannon Horn, Tim Lockhart University of Colorado Boulder
- Phil Wirdzek, International Institute for Sustainable Laboratories (I2SL)
- Moderator Otto VanGeet, NREL
Monica Witt

Los Alamos National Laboratory
Energy Efficient Smart Labs: Lessons from the Leaders

Monica Witt
Laboratory Sustainability Officer
Program Manager, Utilities & Institutional Facilities
Energy Efficient Smart Labs: Lessons from the Leaders

Lessons from the Followers?

Lessons from a Runner-Up?

Lessons from my First Rodeo?

Lessons from the “Try-ers”?

Lessons from someone who was in the right place at the right time?

Lessons from a Smart Lab Groupie?
Lessons from the Followers?

Lessons from a Runner-Up?

Lessons from my First Rodeo?

Lessons from the “Try-ers”?

Lessons from someone who was in the right place at the right time?

Lessons from a Smart Lab Groupie?
Presentation Agenda

- What is a Smart Lab?
- 7 Key Components of a Smart Lab
- Why Smart Labs @ LANL
- Understanding your Target
- Developing an Integrated Team
- Initial Key Steps for Success
What is a “Smart Lab”?  

A laboratory efficiency program created by University of California, Irvine facilities/engineers in 2008.

“Smart Labs” are laboratories that operate at the highest level of safety and energy performance and use a building-specific data stream to continuously monitor and adjust facility conditions.
“Smart Labs” are laboratories that operate at the highest level of safety and energy performance.

“Smart Labs” use a building-specific data stream to continuously monitor and adjust facility conditions.

1. Fundamental platform of dynamic, digital control systems
2. Demand-based ventilation
3. Low power density, demand based lighting
4. Exhaust fan discharge velocity optimization
5. Pressure drop optimization
6. Fume hood flow optimization
7. Commissioning with automated cross platform fault detection
LANL Infrastructure Statistics

- ~40 square miles
  - 7,500 ft. elevation
  - 13 nuclear facilities
- 920 owned buildings with 8.2M gross sq. ft. (owned)
  - 50% more than 40 years old
  - 295 occupied buildings
  - 0.43M gross sq. ft. of leased properties
  - 0.35M gross sq. ft. shutdown assets
- Roads
  - 22 miles of primary roads
  - 62 miles of secondary roads
- Utilities
  - 32 miles of primary power lines
  - 166 miles of secondary power lines
  - 57 miles of gas distribution lines
  - 109 miles of water distribution lines (fire and potable)
  - 28 miles of steam lines
  - 63 miles wastewater

Land comparison of Washington, D.C. and the Los Alamos National Laboratory Site
Age of LANL Operational Buildings by Decade

- **1963-1972**: 868,462 gsf (11%)
- **1973-1982**: 1,102,833 gsf (14%)
- **1983-1992**: 1,195,323 gsf (15%)
- **1993-2002**: 827,612 gsf (11%)
- **2003-2012**: 1,192,690 gsf (15%)
- **2013-2015**: 33,781 gsf (1%)
So many Labs, so little time

- Selected top ten energy using lab facilities
- Institutional commitment through DOE

**Top Ten labs LANL Buildings**

<table>
<thead>
<tr>
<th>Building</th>
<th>Kwh/yr</th>
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<tbody>
<tr>
<td>55-0400 Radiological LAB</td>
<td>8,755,909.00</td>
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<tr>
<td>03-0066 SIGMA</td>
<td>8,650,665.00</td>
</tr>
<tr>
<td>55-0004 Plutonium Building</td>
<td>8,291,750.00</td>
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<tr>
<td>48-0001 Laboratory Building</td>
<td>5,779,268.00</td>
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<td>35-0213 Target Fab</td>
<td>5,299,795.00</td>
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<td>43-0001 Health Research Lab</td>
<td>3,309,255.00</td>
</tr>
<tr>
<td>48-0045 Clean Chemistry&amp;Mass Spectroscopy</td>
<td>3,038,050.00</td>
</tr>
<tr>
<td>03-0141 Beryllium Technology Facility</td>
<td>2,840,959.00</td>
</tr>
<tr>
<td>03-1420 CINT (Center for Integrated Nanotechnologies)</td>
<td>1,981,077.00</td>
</tr>
</tbody>
</table>
Knowing your Target – how many fume hoods are out there?

Over 700 fume hoods over 40 square miles!

- Materials Science and Technology (MST) 31%
- Chemistry (C) 27%
- Earth and Environmental Sciences (EES) 3%
- Materials Physics and Application (MPA) 7%
- Sigma 8%
- TA55 10%
- OTHERS 6%
- Bioscience (B) 8%
What does Success Look Like?

A “Smart Lab” should be:

• **Effective:**
  – Support research and development
  – Flexible to change

• **Safe:**
  – Protect people from exposure
  – Compliance with standards

• **Efficient:**
  – Minimum energy consumption
  – Minimum operating costs

• **Sustainable:**
  – Maintainable with Long Lifecycle
  – Minimum Carbon footprint
  – Return of Investment
Lab Safety & Energy Optimization Process
Roadmap to High Performance Laboratory Buildings

**Issues & Opportunities** → **Remediation/Optimization** → **Safe, Efficient & Sustainable**

**Phase 1**
- Planning & Assessment
  - Goals & Sustainability Initiatives
  - RELSA

**Phase 2**
- Project Funding
  - Align Funding Sources & Project Contracts
- Lab Safety & Energy Optimization Project
  - Engineering & Specifications
  - Construction Renovation Retrofit TAB, CX

**Phase 3**
- Performance Management
  - LVMP
  - Training
  - Routine Test & Maintenance

**Timeline**
- 1 to 3 months
- Phase 2A: 6 months to 1+ years
- Phase 2B: 3 months to 1+ years
- Phase 2C: Multiple Years

**Abbreviations**
- PIM = Performance Improvement Measure
- ECM = Energy Conservation Measures
- TAB = Test, Adjust and Balance
- Cx = Commissioning Tests
- LVMP = Lab Ventilation Management Program
Phase 1 – Planning & Assessment

1. Rapid Energy Laboratory & Safety Analysis
   ✓ Conduct room-by-room hazard review
   ✓ Review chemical inventory/operations
   ✓ Talk with lab staff about processes
   ✓ Evaluate exposure control devices
   ✓ Exposure monitoring

2. Detailed Ventilation Analysis
   ✓ Categorize risk using control bands
   ✓ Establish appropriate operating specifications - minimum lab ACH

3. Select Performance Improvement Measures and Energy Conservation Measures
Facility Components + Organizational components
“Smart Labs” are laboratories that operate at the highest level of safety and energy performance.

“Smart Labs” use a building-specific data stream to continuously monitor and adjust facility conditions.

Remember… Key **Facility** Components of a Smart Lab

1. Fundamental platform of dynamic, digital control systems
2. Demand-based ventilation
3. Low power density, demand based lighting
4. Exhaust fan discharge velocity optimization
5. Pressure drop optimization
6. Fume hood flow optimization
7. Commissioning with automated cross platform fault detection

“Smart Labs” are laboratories that operate at the highest level of safety and energy performance.
Key Organizational Components for Smart Labs

- **Laboratory Ventilation Management Plan**
  - Functional process for repairing fume hoods, installing new fume hoods
  - How are new fume hoods integrated with existing ventilation systems?
  - New hood specifications
  - Categorizing Laboratory hazards

- **Update Engineering Standards Manual**

- **Update P101-16, Industrial Ventilation Procedure**

- **Communicate to tenants/lab users, lab users follow guidance**

- **And, who does all this new/modified stuff?**
Phase 2 – Funding & Implement Optimization Projects

• 10 Year funding proposal for 8 Laboratory facilities focusing on improving facility capabilities for future mission
• Testing design firms for Smart Lab compatibility
Phase 3 – Performance Management

- Training
- Continuous Commissioning
Safe Labs are Energy Efficient Labs

Initial Steps – Keys to a Successful Beginning

Management Commitment
- UCI visited LANL, benchmark trip to UCI
- Commitment to DOE – Smart Labs Accelerator

Integrated Team
- Facility Management, Industrial Hygienists, Scientists
- Subcontractors familiar with Smart Lab concepts

Process Improvement
- Persistence, setting schedules and expectations
- Engineering Standards and Specifications
- IHS Policies & Procedures
Lab Accelerator Program Plan
Air Change Management Program for CU-Boulder

Shannon Horn, P.E. AHJ Campus Mechanical Engineer
Timothy Lockhart, CIH, CHMM Industrial Hygienist
The University of Colorado Boulder has approximately 2.7 million square feet of laboratory space. This accounts for approximately 22% of the total campus square footage and 43% of the total annual energy consumption of the entire campus. All labs were built in different eras with different philosophies and standards regarding Air Change Rate (ACH) and safety.
Challenge for the Campus
AHJs and EH&S

Develop an Air Change Rate Management Program for Laboratories on Campus

- Minimize energy consumption while maintaining form, fit, function, and a safe lab environment
- Determine how this approach could be pragmatically applied to new and existing facilities using available resources
- How to implement the program (Three Phases)

DOE :: May 2017
Air Change Rate Program
Campus Strategy

Phase I (1 to 10 years)
Program Development

Phase II (5 to 15 years)
Program Implementation

Phase III
(15 to 20 years)
Predictive Strategies

DOE :: May 2017
Phase I :: Program Development

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Establish an ACH Campus Standard

- Review of Codes and Standards
- Review Load, Hood, and Hazard
- Review of Laboratory Protocols
- Pilot Study to Validate Assumptions
- Spill Risk Analysis
- Quantify Potential Exposure

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This approach allowed University of Colorado AHJs and EH&S to develop a roadmap that could be applied to laboratory air change rates campus wide.
Baseline Program

Integrate into Campus Processes
• Update Design Standards
• New Construction
• Existing Buildings
  • CX, ReCX, Retro-CX
• Chemical Inventory Program
Implementation Strategies
Reducing Air Change Rates

• Approaches to Reducing ACH
  • Re-balance the system
  • Modify/replace hoods
  • Modify major infrastructure to address DM
    • VAV
    • Fan coil units
    • Conversion to DDC controls

• Laboratory Safety Management
  • Chemical Inventory Program
  • Lab Management and Protocols

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Phase II ::
Program Implementation

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Creating Partnerships

Understanding campus programmatic needs to identify mutually beneficial partnerships

- CU Green Labs
- Administration
- Deferred Maintenance Committee
- Campus Utilities/Energy
- Sustainability
Program Implementation

Prioritizing Buildings
• IAQ Issues
• O&M Calls and Complaints
• Deferred Maintenance
• Energy Intensity

Identifying Viable Funding Sources
• Deferred Maintenance
• Operations Budget
• Energy Conservation Funds
• Research Properties
“Inside each and every one of us is the DNA of success.”

- Baylor Barbee
Program Implementation Initiatives

- Culture
- Funding
- Aligning Partners
- DM Backlog
- Chemical Inventory
- Campus Programmatic Needs

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Chemical Inventory Program

Web-based chemical inventory system for research labs on campus

Beneficial for:

- Regulatory Agencies
- Emergency Responders
- Facilities Planning and Engineering
  - Project design
  - ACH reduction
- EH&S
  - Training
  - Hazard Communication
- Researchers
  - Living inventory
  - Reduction in duplicate or over-purchasing

DOE :: May 2017
Deferred Maintenance Backlog
Discipline Specific

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Pie chart showing the distribution of deferred maintenance backlog by discipline:
- HVAC System: 24%
- Electrical System: 22%
- Plumbing System: 11%
- Exterior Enclosure: 7%
- Structural: 4%
- None Selected: 3%
- Equipment and Furnishings: 3%
- Fire Protection and Interior Construction: 3%
- Other: 2%

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Exploring Potential for 2 ACH (unoccupied)

Safety Awareness and Culture

Improved Chemical Inventory

New Technology

Continuous Commissioning

Continuous Improvement

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Phase III :: Proactive Culture
What Will the Future Hold?

• Predictive Analytics
  • Continuous commissioning
  • Deferred maintenance
  • Artificial intelligence with private sector

• Integrating Finances with Partners
  • Savings are reinvested
  • Examples: ICR Incentives

• Continuous Process Improvement
  • Creating a sense of ownership of all identified partners
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Timothy.Lockhart@colorado.edu

University of Colorado Boulder

DOE :: May 2017
Phil Wirdzek
International Institute for Sustainable Laboratories (I2SL)
Better Building 2017 Summit

Phil Wirdzek, President I²SL
May 16, 2017
I\textsuperscript{2}SL Vision and Mission

- **Vision**
  - I\textsuperscript{2}SL is the global leader and primary resource connecting all stakeholders and providing information and education to ensure safe, sustainable laboratory design, operation, and use.

- **Mission**
  - To engage all stakeholders in advancing the safety and sustainability of laboratories and other high-tech facilities both nationally and globally.
Educational Opportunities

• Quarterly e-newsletters, regular webinars, and annual conferences

• Provide access to industry expertise through I²SL’s Community of Members, Chapters, and Providers

• Topical working groups, committees, and technical assistance led by I²SL Members

• Targeted professional training and education providing Continuing Education Credits
I²SL’s Global Community

- **I²SL Membership** – individuals committed to I²SL’s mission, having expertise that shapes I²SL’s activities

- **I²SL Chapters** – city, regional, or broader groups of professionals that work together to promote I²SL mission through networking and education

- **I²SL Providers** – firms and organizations providing services, technologies, and consulting consistent with I²SL’s mission
Current I²SL Initiatives

- Development of O&M Curriculum (academia and industry)
- Laboratory Continuous Performance Improvement Program (academia and industry)
- University Alliance (academia, industry, government)
- Updating Labs21 Tool Kit, including the Labs21 Benchmarking Tool (Members)
- Third-Party Financing (industry and U.S. DOE)
- BIM as an High Tech O&M/FM Tool (NIBS and IFMA)
- DOE Smart Lab Partnership
A Collaborative Grant Between DOE and I²SL for the Smart Lab Accelerator Program

- I²SL Members to Recruit Smart Lab Accelerator Partners
- I²SL Members to Provide Program and Technical Assistance
- I²SL to Provide Technical Tools and Training
- I²SL to Support Partner Promotion
To Be a Smart Lab Partner?

- Desire to reduce operating costs
- Recognize that labs costs money
- Savings with energy efficiency
- Know the condition of your labs
- Consider the partnership goals
  - Baseline your lab
  - Meter for accuracy
  - Project objectives meet goals
  - Implement and share
I²SL Tools and Training

• Elements supporting partners:
  – Roadmap of applicable concepts
  – Support through I²SL members
  – Benchmarking for Laboratories
  – O&M Training and Certification
  – Management for Continuous Improvement to meet Goals
  – Energy Efficiency and Environmental Sustainability in Research Grants
The Lab Benchmarking Tool (kW Engineering)

- A new, enhanced benchmarking tool for lab buildings
- Replaces the venerable Labs21 Benchmarking Tool
- Continues long-term collaboration between I^2SL and LBNL

The new Lab Benchmarking Tool will:

- Retain access to the unsurpassed Labs21 dataset, crowdsourced over past 15 years: 639 buildings, 120 million sf (5% of US total)
- Provide a completely new user interface with new graphing capabilities
- Contain expanded data fields, additional building assessment metrics, case studies, and improved data quality control
Expanded Data Fields

- Modernized, more granular functional requirements:
  - Modern lab building types, e.g. integrated science centers, biotech incubators, nanotechnology labs
  - Ventilation rates/hazard classifications
  - Process loads

- New featured metrics for building comparison:
  - Water usage
  - Energy cost
  - Energy score (see next slide)

- Improved data QC

- Additional resources to improve actionability:
  - System-level benchmarking references
  - Accelerator partner case studies
  - I²SL best practice guides
An Energy Score for Labs

• Explore development of a rating system for labs
• Use highest quality data from database
• Regression analysis based on lab-specific functional requirements
• Akin to an ENERGY STAR score
• Easier to gauge and track a building’s performance
Managing Laboratories and Critical Control Environments

- Government
- Universities
- Chemical
- Biotechnology
- Pharmaceutical
- Industry

- 17,000 Laboratory Facilities in the United States (LBNL 2016)
- Expensive to build and operate (e.g. high energy consumption)
- Complex and challenging to manage and maintain
- Wide spectrum of risk and potential for liability
Challenges

• Dynamic Research & Change in Processes
  – Trigger points to identify changes in lab operations
• Ongoing Risk Assessment
• System Modifications
• Component Degradation
• Component Failures
• Diminished Service and Support
• Consistency and Quality of Maintenance

Ensuring lab safety and energy savings is not “sustainable” without ongoing risk assessment, management of change, integration of facility stakeholders and training!
I2SL - Lab O&M Training Survey

2012 Survey “Exploring the benefits for proper training of high tech facility operations and maintenance professionals”

47 Respondents including facility managers and O&M stakeholders

Highlights:

• 70% indicated detailed knowledge of ventilation system design, engineering and activities of the users are necessary.

• > 70% indicated O&M and PM responsibilities involve understanding the role lab ventilation for managing risk.

• 76% indicated understanding requirements for roof access and servicing of potentially hazardous ventilation equipment are necessary.

• > 70% indicated personnel should be familiar with research activities and methods for building relationships and communicating with other facility stakeholders.
Training for High Performance Lab Ventilation Systems

• Module 1: Leading a Smart Labs Management Program (1 day)
  – Part 1. Organizational Benefits, Leadership Requirements and Costs (2 hr.)
  – Part 2. Performance Goals, Resource Allocation and Program Management (6 hr.)

• Module 2: Managing Smart Labs (2 day)
  – Part 1 - Stakeholder Coordination, Roles and Responsibilities
  – Part 2 - Design, Operation and Management of Change
  – Tasks, Schedules and Deliverables
  – Proficiency Exam to Qualify Personnel for Proceeding to Module 3

• Module 3: Smart Labs Specialist (7 days Intense Hands On Training)
  – Part 1. Laboratory Ventilation Performance, Testing and Maintenance (3 days)
  – Part 2. Lab Ventilation Controls and Building Automation (2 day)
  – Part 3. Mechanical Systems Operation and Maintenance (2 day)
  – Competency Exam for and Certification
Continuous Improvement Tool: Commissioning the People
Staffing and Systems = “Stakeholders”

Facilities
Automation/BAS
Safety
Researchers

Building
Design
Capital
Planning

May work in silos
Upgrades are Complex:

- Technology
- Finances

? Stakeholders

A lagging stakeholder may hold up an upgrade when technology and finances are available
## Detailed Content in Each Cell

### MATURITY MATRIX

<table>
<thead>
<tr>
<th>Stage</th>
<th>Facilities</th>
<th>BAS</th>
<th>EHS</th>
<th>Lab Workers</th>
<th>Building Design</th>
<th>Capital Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity</td>
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<td>5 Optimizing</td>
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1. Face Velocity ±5%
2. Hood Hibernation SOP
3. Controls visible in field
## Maturity Matrix

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</thead>
<tbody>
<tr>
<td>5 Optimizing</td>
<td>Freezers located in hallways/alaroves - space not designed for ULT Freezers</td>
<td>Individual researchers with some of ULT freezers that are connected to an alarm notification monitoring temperature</td>
<td>No published disposal guidelines</td>
<td>No sample management, no filter or coil cleaning</td>
<td>HVAC undersized, no air management</td>
<td>No procurement standards; Take ULT Inventory by counting or through Material Management office &gt; 52,000 items</td>
</tr>
<tr>
<td>4 Integrated</td>
<td>Freezers hooked up to emergency backup</td>
<td>Individual researcher with ULT freezers connect to alarm notification monitoring current and temperature</td>
<td>Biohazard and Hazardous waste guidelines published</td>
<td>Some Sample Management and Consolidation, Maintains Freezer filters and coils</td>
<td>HVAC oversized, no air management</td>
<td>Established list of energy and space efficient ULT freezers that have been measured through a 3rd party</td>
</tr>
<tr>
<td>3 Standardized</td>
<td>Freezers are connected to emergency liquid nitrogen backup</td>
<td>&gt;25% of ULT freezers are alarmed centrally;</td>
<td>Central Collection points for Biohazards</td>
<td>Using RTSS for Shipping; &gt; 25% of inventory in database</td>
<td>Good Air Management - Supply Air introduced in the front and Exhaust Air is pulled from the rear (hot &amp; cold aisles)</td>
<td>Centralized strategy of targeted models</td>
</tr>
<tr>
<td>2 Managed</td>
<td>Centralized Freezer Farm for Archival Storage of Samples</td>
<td>&gt;50% alarmed centrally; 5% monitored for current and temperature with central administrator</td>
<td>Central Collection points for Biohazards</td>
<td>Utilizing Room Temperature Storage for &gt; 5% of samples; &gt; 50% of inventory in database</td>
<td>Air economicizing, water cooling considered</td>
<td>Phased replacement of ULT freezer reaching end of life</td>
</tr>
<tr>
<td>1 Individual</td>
<td>Centralized Freezer Farm designed with good air management, and support staff to respond to freezer failures, maintain freezers, and manage samples</td>
<td>&gt;90% ULT freezers connected to an alarm notification or monitoring current and temperature</td>
<td>Disposal assistance available</td>
<td>&gt; 75% of inventory in database</td>
<td>Utilizing reject heat</td>
<td>Purchase of alternative ULT freezers such as water cooled, liquid nitrogen, and Sterling Engine</td>
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### Not Reaching Goals Can Motivate New Resources

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Get Started by Contacting

FIND: Otto VanGeet
Otto.vangeet@nrel.gov
National Renewable Energy Laboratory

Seek a local I²SL Chapter (or Member)

http://i2sl.org/globalcommunity/chapters.html
http://projects.erg.com/conferences/i2sl/members/members.asp

FIND: Phil Wirdzek or Beth Shearer
philwirdzek@i2sl.org
Beth.shearer@Comcast.net
ALSO: info@i2sl.org

Or call Phil at 540.843.2005
Issues to Discuss

• Who Knows the condition of their labs?
• Since you care, where would you start?
• Would being a partner be useful?
• What elements are challenging?
• Is financing a project difficult?
• When would you get started?
Thank You

Provide feedback on this session in the new Summit App!

Download the app to your mobile device or go to bbsummit.pathable.com
Resources and Supporting Documentation

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The campus has reported approximately 1 evacuation event per year for 2.1 million square feet of laboratory space.

Based on this data point the University has less than a 1% chance based on any given lab evaluated that the incident will occur in a particular space.

If an event does occur, the exposure is limited further by the evacuation procedures in place.
Quantify Lab Hazard Assumptions in the Event of a Spill with:

Modeling - mathematical calculations

Monitoring - mock spill scenario and real time monitoring of spaces

*Estimating acetone concentration over time for comparison to occupational exposure limits*
Generation and Degradation of Acetone Concentration
Monitored & Modeled Data (4 ACH vs. 19 ACH)

OSHA PEL – 1,000 ppm
ACGIH TLV – 500 ppm
STEL – 750 ppm
NIOSH REL – 250 ppm

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Questions and Considerations

- Phase III :: In Progress (2022 to N)

  - Campus Data Analytics
    - Smart analytics programs
    - Continuous commissioning will evolve into more predictive analytics
  - Automated program integration of
    - Changes to space
    - Program changes
    - Chemical inventory
    - Safety training

- Financial
  - Maintenance budget for the program verses capital mechanisms described in Phase I and Phase II
  - Reduce campus overhead for energy and operations Predictively using this as a mechanism to fund from energy and deferred maintenance savings
  - Reduces capital expenditure rebate incentives with building occupants

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http://www.air-dispersion.com/msource.html#Non-Boiling

“IH Mod” American Industrial Hygiene Association, Exposure assessment Strategies committee http://www.aiha.org/insideaiha/volunteergroups/Pages/EASC.aspx
Proposed Agenda:

Intent: To determine and come to a consensus on acceptable minimum air change rate and/or CFM/sq ft. for laboratories for new and existing buildings across campus:

1. Drivers effecting ACH (Health and Safety, and energy consumption)
   a. Codes
      i. IBC B occupancy or H occupancy for laboratories (B occupancy does not stipulate a lower limit, H does)
      ii. IFC (B occupancy no stipulation, H has lower limit requirements)
      iii. IMC ventilation based on cfm/sq. ft and type of space and pollutant generation.
   b. Adopted Standards guidelines (How are we using these on campus as adopted standards or guidelines.)
      i. NFPA 45 2003, (4 unoccupied, 8 occupied)
      ii. NIH building requirements not known, needs to be investigated further
      iii. ASHRAE Laboratory Design guide -2001 (4 to 12 ACH, performance based on containment)
      v. ACGIH, 24 ed. Wide range (Does EH&S have these standards)
      vi. ANSI/AIHA Z9.5-2003 Wide range (Does EH&S have these standards)
   c. Industry Standards: Engineered Solutions, CFD modeling, contaminant detection.
   d. Other drivers based on EH&S, UCB Fire Marshal and UCB mechanical Engineering not mentioned above, i.e. ACH calculations based on 10 ft high ceilings vs total volume.

2. Determine which of the above we will be enforcing, using as a guideline or other approach.

3. Conclusion provided Labs are B occupancy
   the AHD + EH&S base ACH in labs
   based on performance & type of research.
Occupational Exposure Limits
Reviewed

- OSHA PEL – 1,000 ppm
- ACGIH TLV – 500 ppm (NIC -200)
- STEL – 750 ppm (NIC-500)
- NIOSH REL – 250 ppm
- IDLH – 2,500 ppm
- LEL – 25,000 ppm

DOE :: May 2017
Lessons Learned and Recommendations

• Altering sample locations
• Measuring “dead spots” of airflow
• Smaller volumes of material
• Not in trays…directly on floor (or similar)
• DO NOT DISTURB THE ACETONE!
• Each building system needs to be evaluated with the above approach
• Team approach was instrumental in the implementation of the project, high caliber students, BAS technicians, LWEEP program, and lab users cooperation
Pros and Cons of Modeling

Pros
• Cost effective
• Adjustable for multiple compounds
• Easily altered variable

Cons
• Overly conservative
• Based on assumptions
• Does not account for:
  • Laboratory layout
  • Airflow patterns
  • “Dead zones” or areas of limited airflow
  • Room thermals
Consistency Between Assumptions and Variables (Modeling and Monitoring)

Variables

- Temperature and Pressure
- Room Volume
- Airflow Rates
- Dimensions and geometry of spill (length, width, depth)
- Chemical Properties (i.e. VP, MW, SG)
- Air exchange Rates
- Evaporation Rate
- Even mixing

Assumptions

- Wind Speed over spill (0.09 m/s for 4 ACH and 0.254 m/s for 19 ACH)
- 0 ppm Acetone in supply air and background of laboratory
- Even mixing in lab
- Spill is on the floor of a laboratory
- Hazardous chemicals would be used in a hood or with LEV
Pros and Cons of Monitoring

Pros

- Real life scenario
- Laboratory specific
- Actual air concentrations shown over time

Cons

- Expensive
- Based on assumptions
- Individual compounds
- Can’t extrapolate to other areas
- Hard to conduct and obtain lab space to conduct to tests