Laboratory Ventilation Flow Rates at Cornell: Rethinking the Tradition

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Agenda

1. Laboratory Ventilation as part of the Laboratory Safety System

2. Cornell's lab air reduction practices

3. Moving forward: the Laboratory Ventilation Management Plan

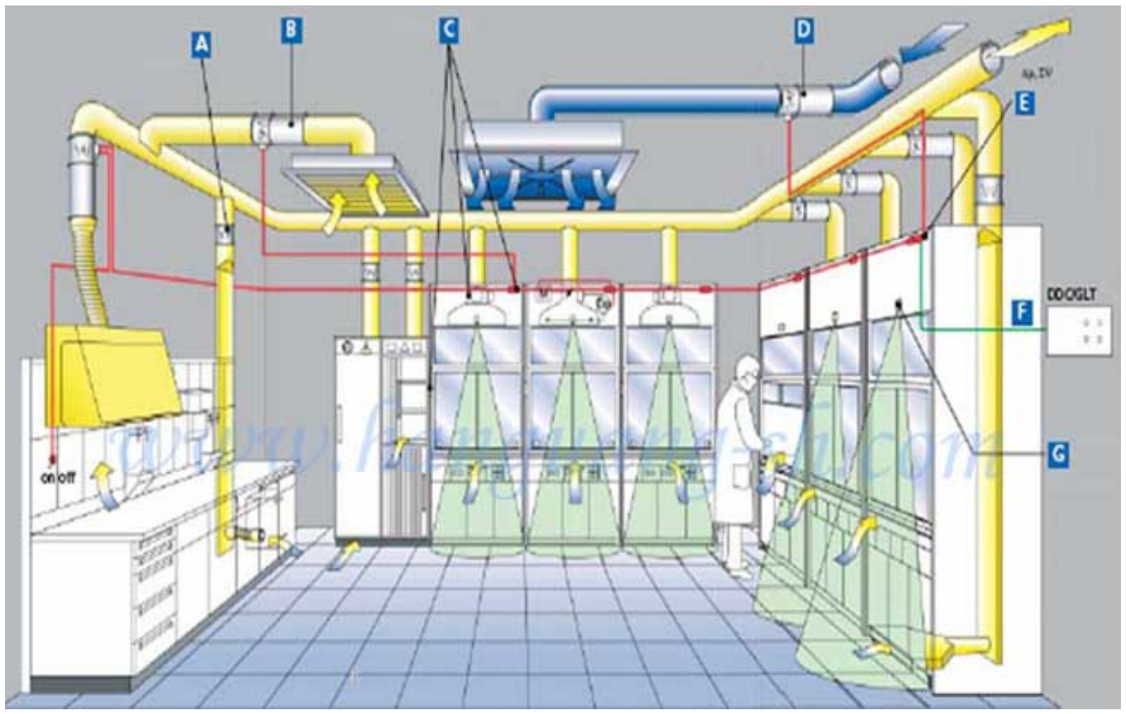
What is a Lab?

- Laboratories are workplaces where people do unusual things with hazardous materials
- Generic strategies are used to protect the workers and their science:
  1. *Hazard replacement or downsizing*
  2. *Facility design and operation*
  3. *Worker training and oversight*
  4. *Personal protective equipment and emergency response plans*

- This flexible approach to safety maximizes the kinds of work the facility can host

Today's Lab Ventilation System

- Fume hoods
- General Laboratory Ventilation
- Chemical Storage Cabinets



General Lab Ventilation Specifications for Safety Purposes

- **Air Quality:** use 100% outside air to avoid recirculating contaminants originating in the lab

- **Air Quantity:**
  - The late 20th century approach:
    10-12 ACH 24/7 in all labs
  - The 21st century approach:
    ACH depends on what's happening in the room and how effective the ventilation is
- Ventilation requirements can be driven by:
  - Control of chemicals and other hazards
  - Local exhaust requirements
  - Temperature (solar and plug load)

Energy Conservation Initiative Program

- Campus wide multi-phase plan (2002 – 2017)
- Goal is to reduce year-2000 energy use 20%
- Program includes energy conservation focused maintenance, studies, and projects – data driven
- Program supported by NYSERDA rebates

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Key energy conservation opportunities in laboratories

- Re-commissioning control systems to reduce outside air use
- Use occupancy sensors to control occupied / unoccupied air flows and lighting
- Relax temperatures during unoccupied time to reduce reheat requirements
- Retrofit environmental chambers

Reducing General Air Flow using CFD modelling

- A full 3D CFD model was built in Fluent software for 3 buildings (one 1950's, one 1980's, one 1990's renovation)
- Results showed that in the 1980's building (Bioteach), 8/4 was not clearing spills effectively
- Model results were verified by qualitative smoke tests

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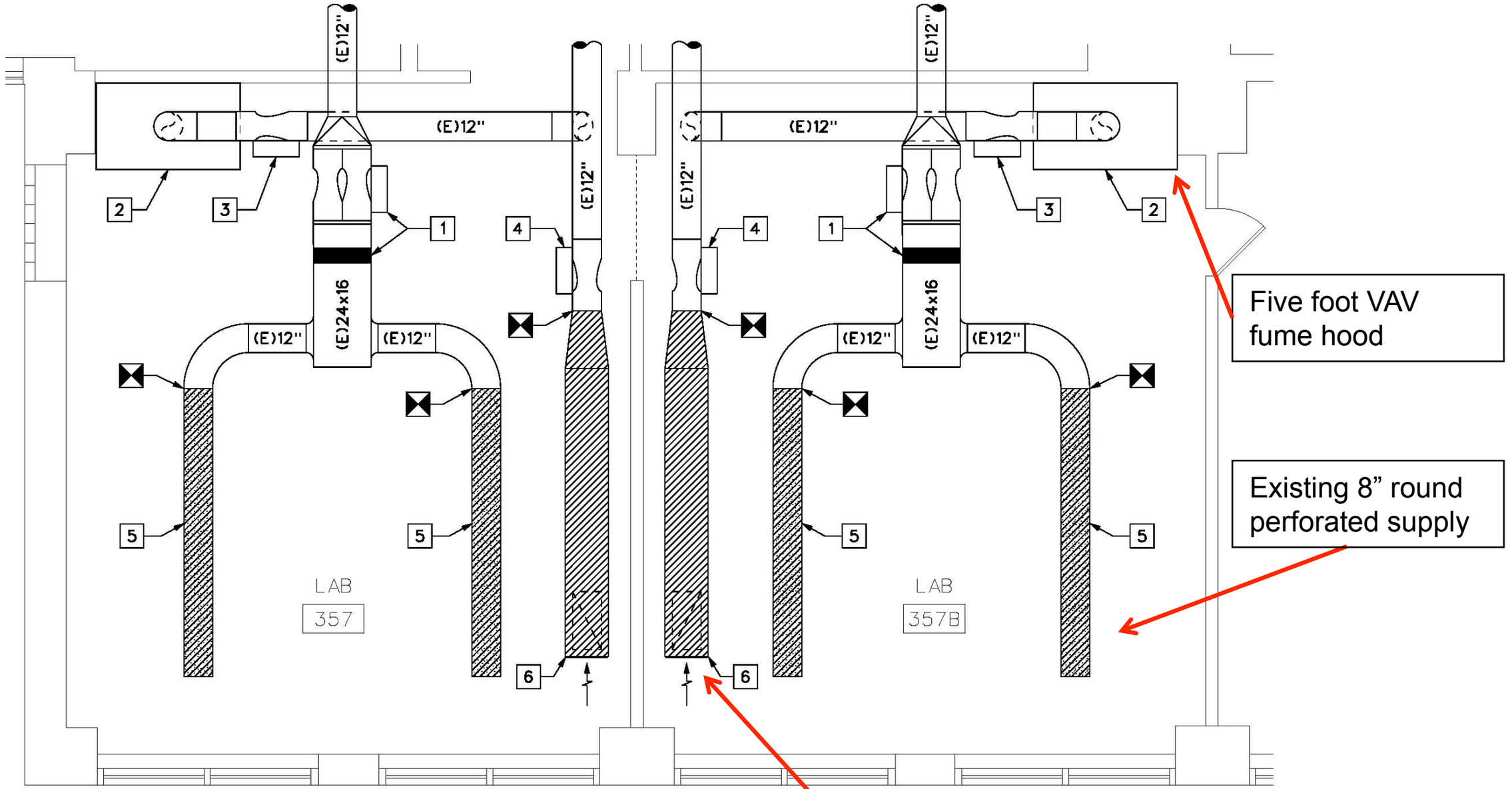
Biotechnology existing ductwork



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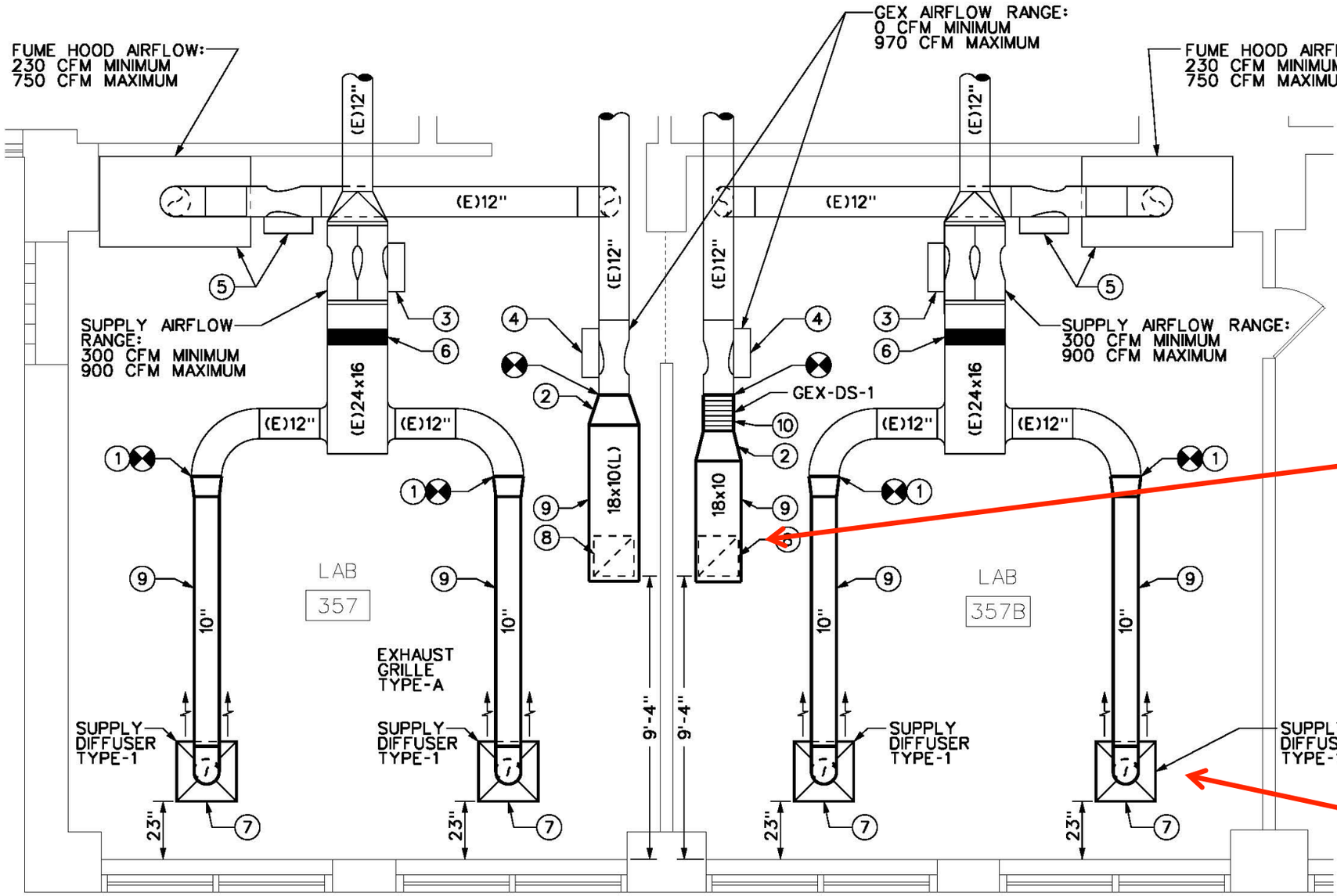
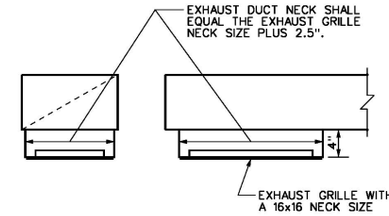
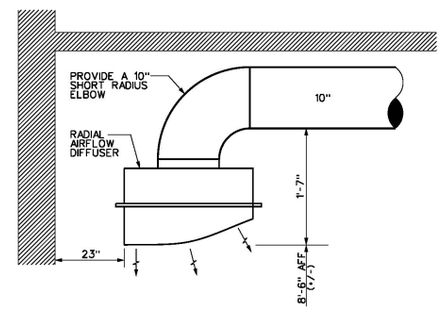
Biotechnology new ductwork design





5 H1.1 GENERAL EXHAUST GRILLE DETAIL
SCALE : 1/4" = 1'0"



4 H1.1 SUPPLY DIFFUSER DETAIL
SCALE : 1/4" = 1'0"

Biotechnology building results

- CFD modeling found that, after redesign, spills were cleared well enough at 6/3 to avoid OSHA PELs
- 90 fume hood zones = ~ $180,000 renovation cost
- Savings ~ $1200/lab each year, less than a 2 year simple payback!
- Building operating costs went from $1.2 million/year to $900,000/year

Lessons Learned (2008)

- Cornell's historic building stock means that the general ventilation decision is not as simple as "just do it"
- Ventilation effectiveness in a lab must be evaluated on a room basis
- CFD is a cost effective tool to evaluate current and proposed designs

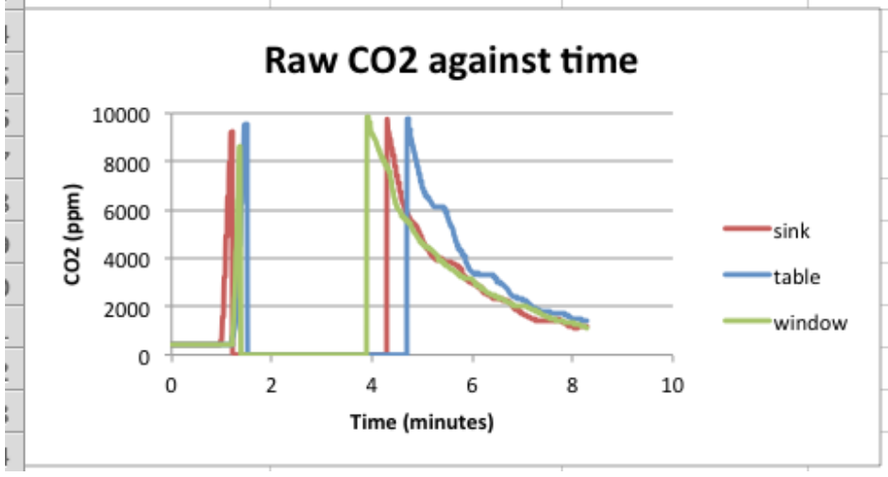
The Next Phase: Control Banding Labs

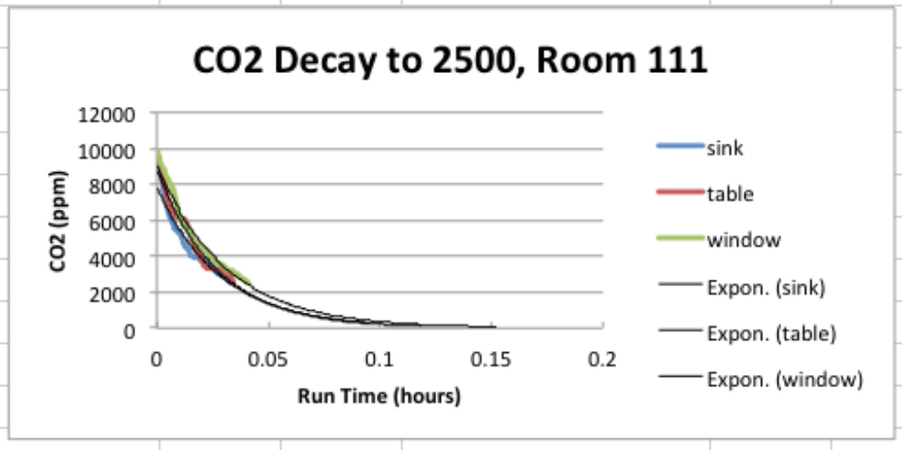
- We start with a standard minimum of **8 ACH** when the lab is unoccupied and **4 ACH** when unoccupied to control chemical concentrations (temperature and exhaust can override these minimums)
- We review the current chemistry to identify labs where **6 ACH** and **3 ACH** can be expected to control chemical hazards.
- There are special cases outside these generic categories (e.g. animal areas, BSL rooms and machine shops (once through air at around 2 ACH)).
- Over the last 1.5 years, we have visited about 600 laboratories at Cornell and the majority can run at 6/3, *if fumes hoods are used and ventilation is effective*

Evaluating the Ventilation Effectiveness Caveat

- We use fire extinguishers to release CO2 and measure chemical concentration decay patterns within a laboratory

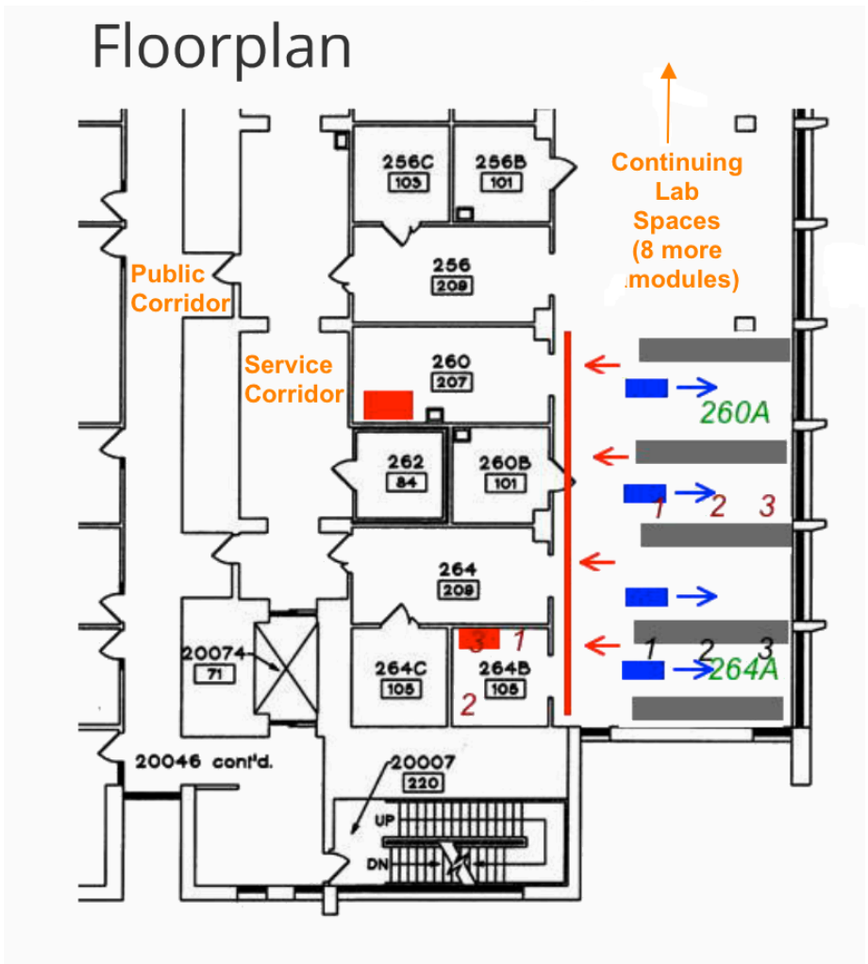
Location of sensor	sink	table	window		BCS ach rate
Number of data points	122	126	150		
Observed ACH	34.84	37.06	32.40	per hour	38
r-squared	0.95	0.97	0.98		
Concentration half life	1.19	1.12	1.28	minutes	



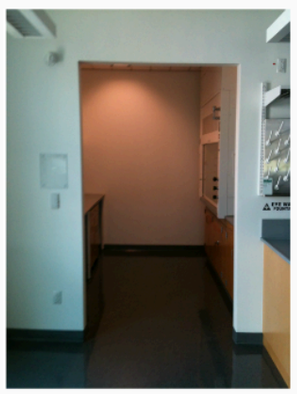


Another Ventilation Reduction Opportunity

- Weill Hall: large, open lab concept building occupied in 2008
- Has been running at 8/4, as designed, with some labs in “Vacant mode”
- Can this building run at 6/3?



Lab Layout Details



Hood alcove 264B

264A aisle and 264B

View into 260

Decay Measurement Results

Run number	Source room(s)	260 ach	260 aisle	260 middle	260 window	*260 average*	264 ach	264 aisle	264 middle	264 window	*264 average*
1	264 and 260	8	10.1	7.2	-	*8.6*	8	10.2	8.0	8.9	*9.0*
2	264	6	53.2	32.2	11.3	*32.2*	6	17.9	16.3	14.9	*16.4*
3	260	6	9.2	11.0	13.2	*11.1*	6	4.4	8.3	10.4	*7.7*
4	264	8	8.3	10.4	11.6	*10.1*	6	10.3	9.8	10.9	*10.3*
		r-squared									
1			0.98	0.99				0.93	0.97	0.95	
2			1.00	1.00	0.96			0.95	0.98	0.93	
3			0.81	0.93	0.99			0.67	0.83	0.97	
4			0.82	0.83	0.98			0.76	0.82	0.98	
		half life (minutes)									
1		5.2	4.1	5.8		4.8	5.2	4.1	5.2	4.7	4.6
2		6.9	0.8	1.3	3.7	1.3	6.9	2.3	2.5	2.8	2.5
3		6.9	4.5	3.8	3.1	3.7	6.9	9.4	5.0	4.0	5.4
4		5.2	5.0	4.0	3.6	4.1	6.9	4.0	4.3	3.8	4.0

Room	Pressure	Supply	Exhaust	ach
264A	neutral	866	864	8
260A	negative 100	672	772	6
260a	negative 100	918	1010	8
264A	neutral	626	629	6

ceiling tiles are 1 by 4 feet
diffuser to window distance is about 16 feet
wall to window distacnce is about 20 feet
260 and 264 are 41 feet wide collectively

Conclusions

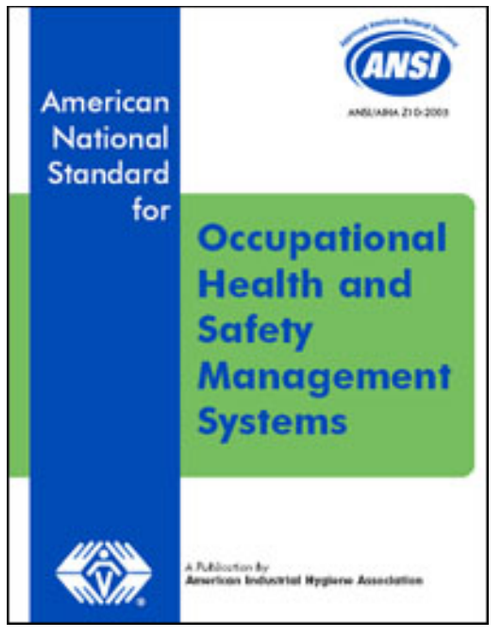
- The open lab concept increases ventilation effectiveness by providing more room for chemicals to diffuse
- There are specific areas of concerns at the edges of the room – windows, doorways, etc.
- It is important that odoriferous chemicals are used in fume hoods
- This building can run at 6/3 safely

Operational Results

- Effectiveness testing began in February, 2012 and was completed in May
- Recommendations were delivered to building management and occupants in August, 2012
- Implementation hurdles are being addressed
- Switch over of second floor on pilot base is underway.
- Savings expected to be $300,000/year and 100 homes of carbon/year

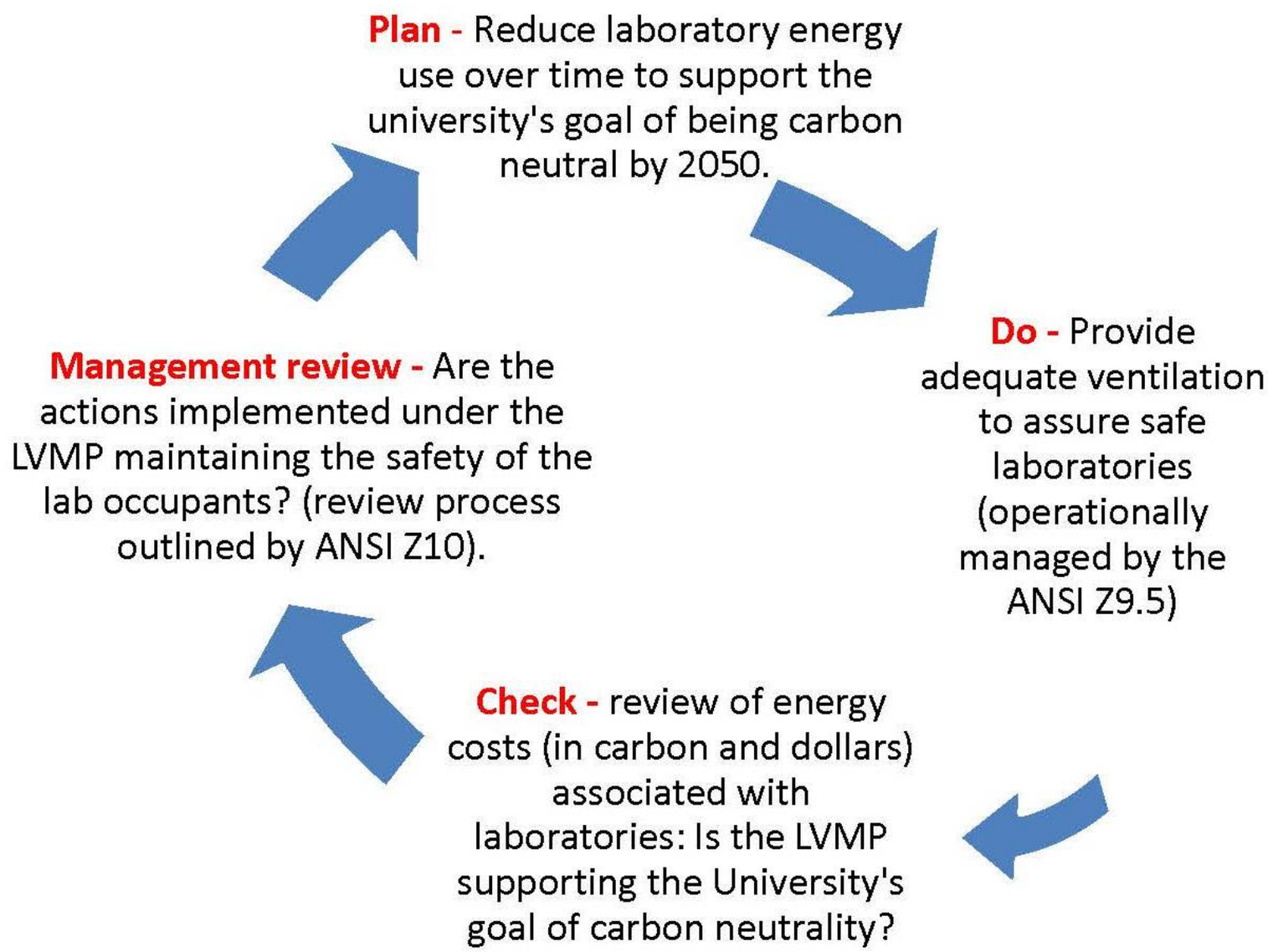
Maintaining the Lab Vent System

- Managing within Systems
  - Systems include multiple priorities associated with a variety of stakeholders
  - Systems can be simple (a change results in a predictable outcome) or complex (a change results in a variety of outcomes, some predictable)
  - Managing within a system requires flexibility and practice
- Laboratory ventilation managers face competing priorities (science, safety and sustainability)
- Fortunately, we have ANSI Z9.5 and Z10 to help guide the system



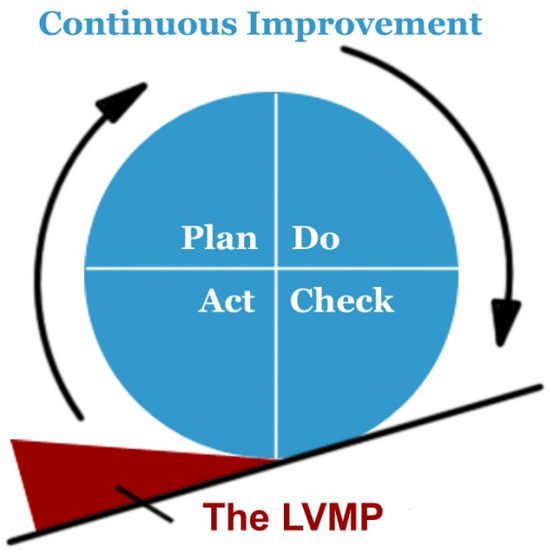
Questions?

The LVMP Management System



Coming to a web site near you soon!

The LVMP: Lab Ventilation for Science, Safety and Sustainability



Stakeholder Group	Primary Phase	Specific Activities
Facility designers	Plan	Specify laboratory equipment and operating parameters
Laboratory users	Do	Use of hazardous materials in a way that manages those hazards
Facility operators and management	Check	Continuously commission lab ventilation systems; certify hood face velocity; track HVAC energy use in labs
EHS staff and academic management	Act	Review laboratory ventilation practices for opportunities to improve safety and sustainability

Tracking Improvement: Identifying Indicators and Setting SMART Goals

Stakeholder Group	Indicators	Specific Activities
Facility designers and academic management	Average ACH specified	Reduce specified ventilation rates by greening chemistry and improving hoods purchased
Laboratory users	Hood housekeeping scores	Maintain good housekeeping
Facilities management	Total energy used to maintain lab ventilation parameters	Track HVAC energy use in labs
EHS staff and academic management	Number of events related to ventilation rates	Track hazmat responses and IAQ concerns related to ventilation rate

Other ACH's

- "Occupancy" ventilation rate (20 cfm/person) where there is no chemical driver – for example, electron microscopy and other instrument heavy labs

Summary: Key Laboratory Ventilation Conservation Opportunities

- Identify hoods that can be hibernated
- In exhaust-driven labs, reduce face velocity on hoods that can maintain containment at lower flowrates, either through VAV or low flow hoods
- Set default general lab ventilation ACH to 6 when chemical processes allow