Know Your Constraints: Proven, Safe Results of Lab Building Optimization

Presented by:

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Learning Objectives

1. Be able to identify and properly account for design constraints in existing lab building design and commissioning projects.

2. Understand the role a commissioning agent has in the design, construction, operation, verification, and training of staff in new construction or major renovation.

3. Obtain a greater understanding of lab ventilation equipment and control theory.

4. Be able to identify major areas of energy consumption and potential wasted energy in lab buildings

RCx in Existing Labs

- Re/Retro Commissioning is a process that when executed properly, helps ensure lab building equipment and systems will meet current lab use and updated owner requirements WHILE prioritizing lab safety and energy conservation.

- Important!
  - **Lab use changes over time** – there is often major differences between design/anticipated use and current use!
  - Code Changes

- Need to evaluate the current use of labs, examine existing equipment and ensure the labs and building operate to meet the current use.

Optimizing Ventilation for Current Use

1
- Consult EH&S and appropriate stakeholders
- Determine minimum, safe ventilation

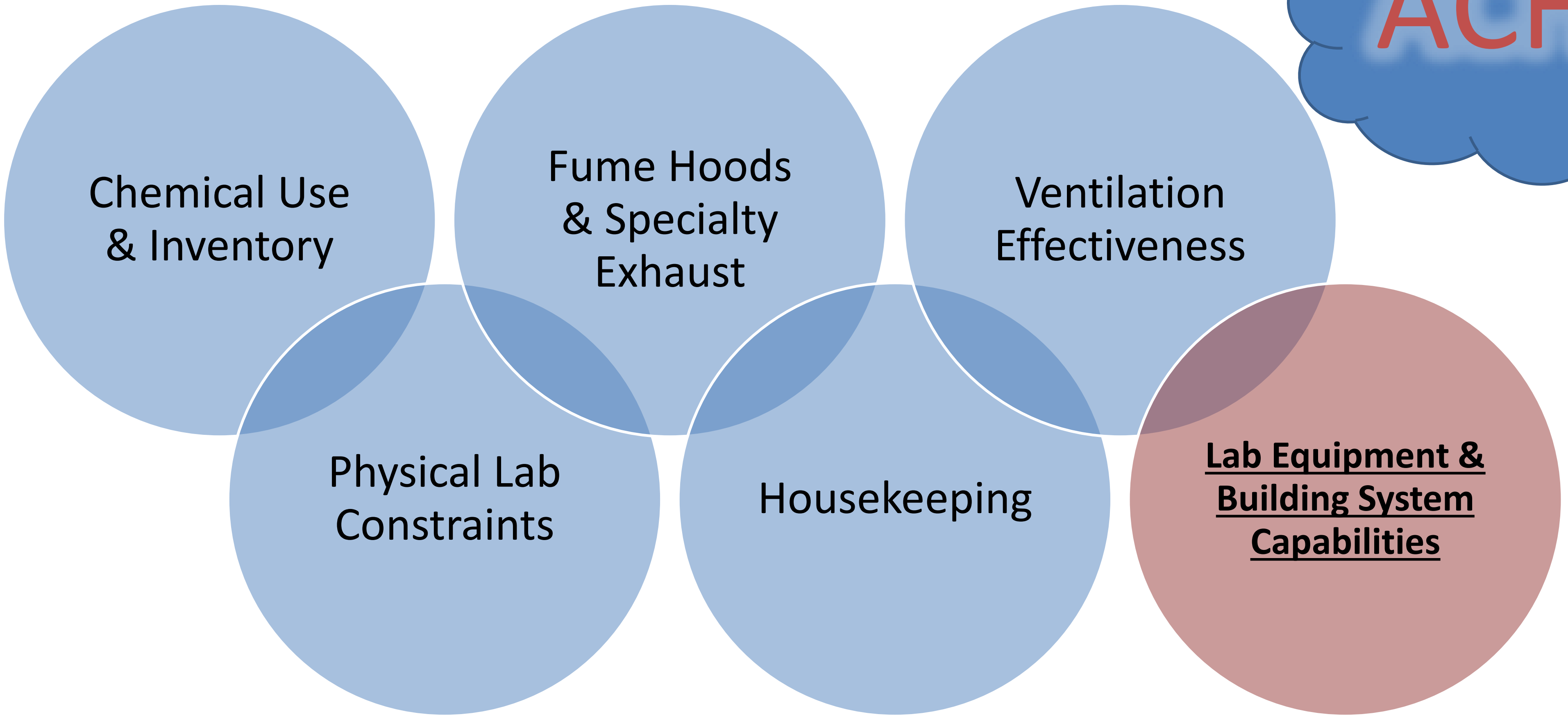
2
- Determine corresponding ventilation setpoints per EH&S recommendations.

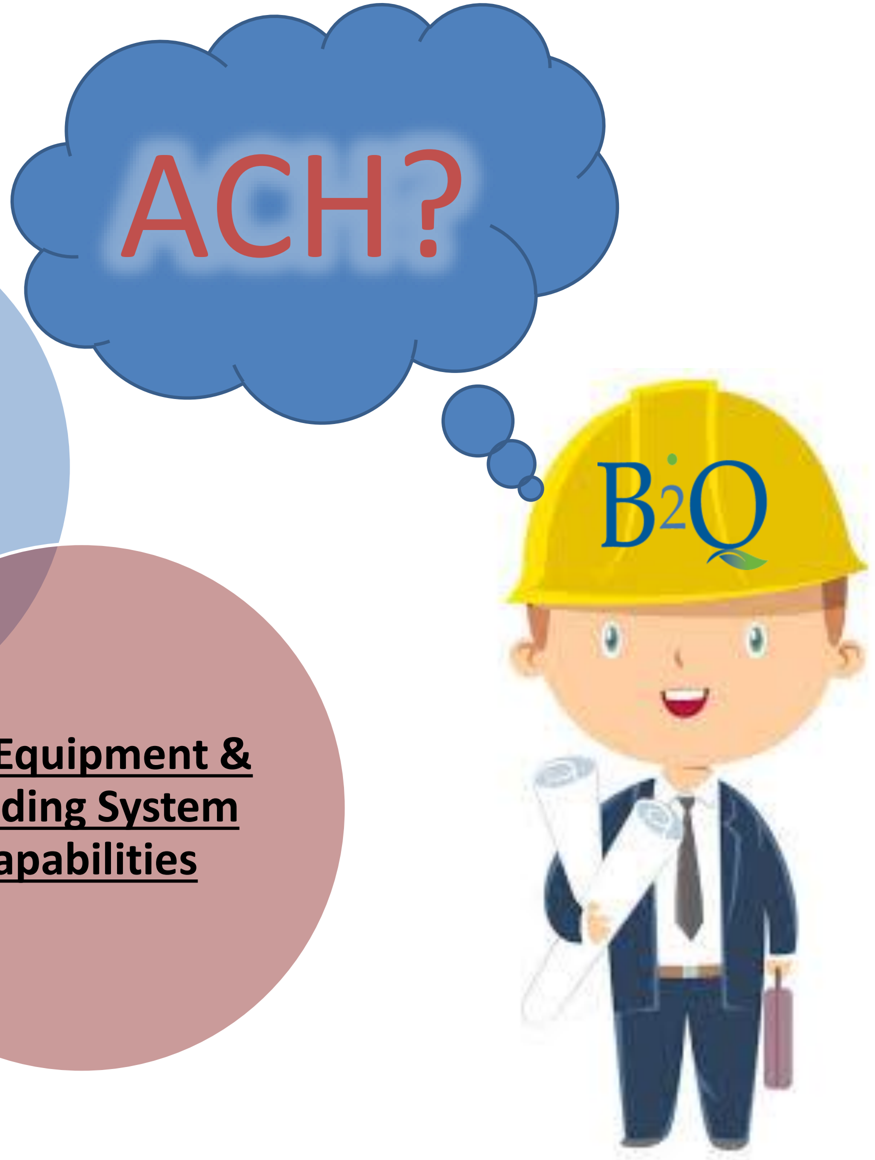
3
- **Evaluate lab system and equipment capabilities**
- Revise ventilation setpoints accordingly

4
- Implement, commission and verify new setpoints

Evaluate Energy Savings & Potential Utility Incentives $$$

Ventilation Reduction – How Low Can You Go??





EH&S Minimum ACH

Chemical Usage Review

- Review chemicals in labs for:
  - Flammability
  - Toxicity
  - Odor

Ventilation Effectiveness Review

- Development of low flow areas, “dead zones” or diffuser layout concerns

Housekeeping Review

- Cleanliness of the lab zone is examined to determine risk

Codes & Internal Standards

This is the lowest ventilation obtainable for each lab!

Calculating Exhaust from ACH

Given by EH&S

Physical Constraint

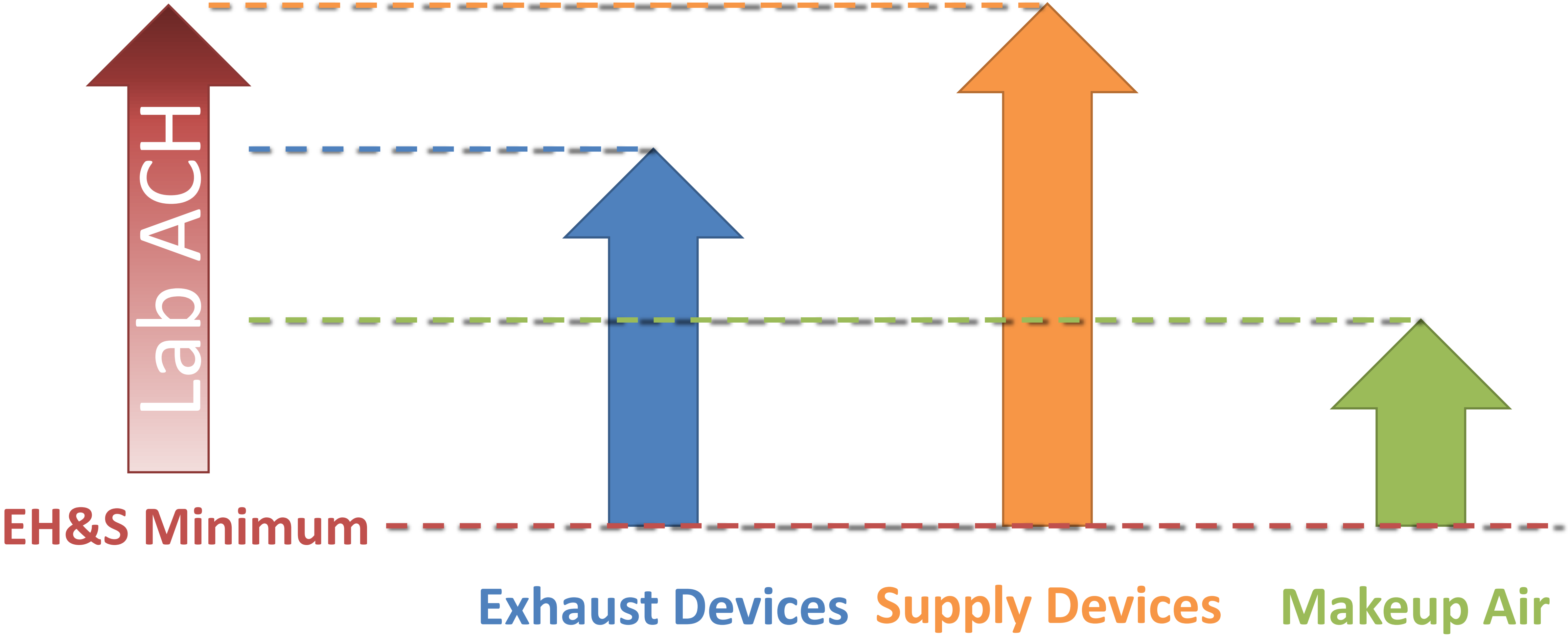
$$Total\ Exhaust\ Airflow\ \left(\frac{ft^3}{min}\right) = \frac{Air\ Change\ Rate\ (ACH)\ x\ Net\ Lab\ Volume(ft^3)}{60\frac{min}{hour}}$$

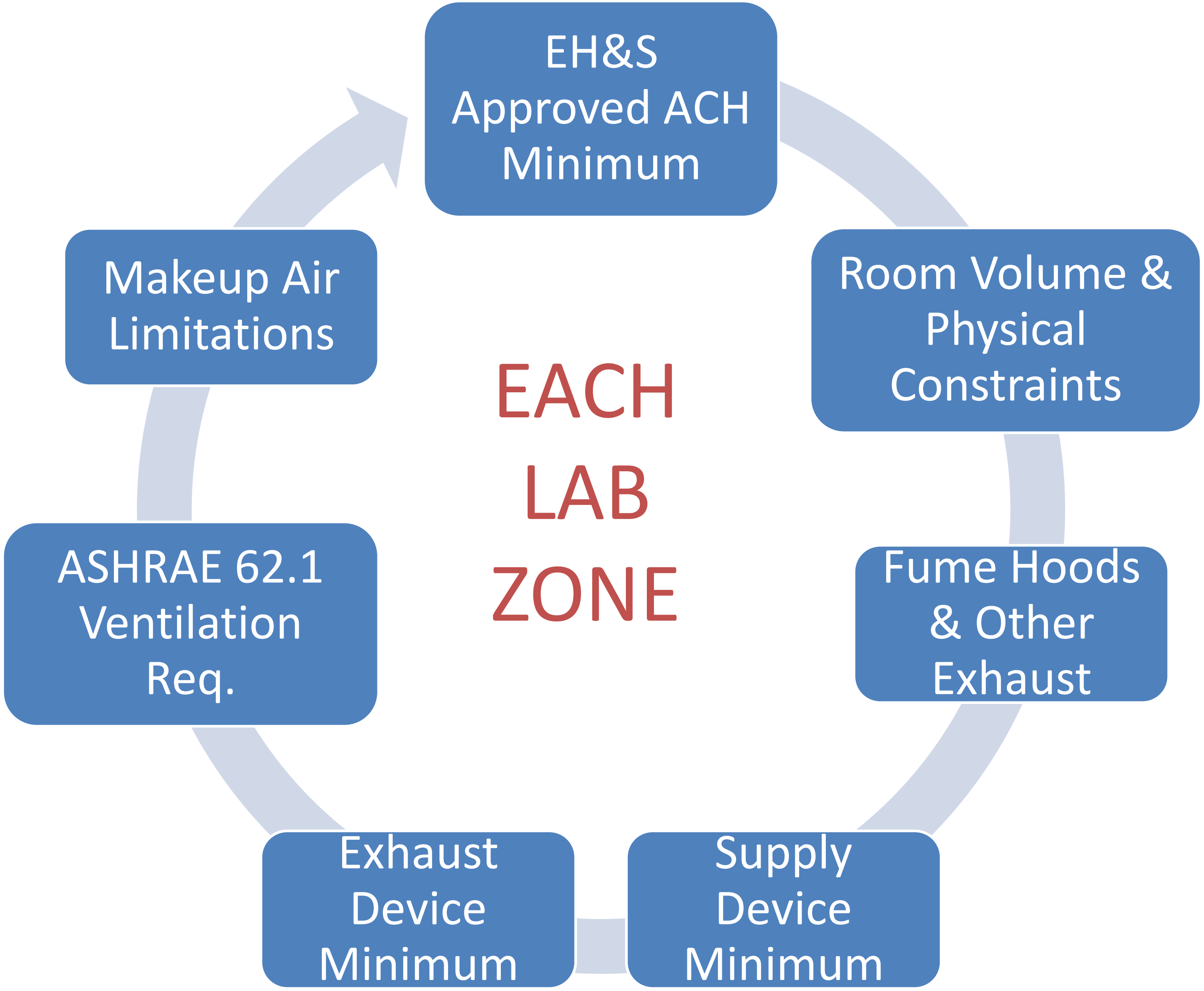
<u>Lowest Possible Total Lab Exhaust to Meet EH&S Requirements</u>

- Example Lab 1: EH&S Approved 6 ACH Occupied & 3 ACH Unoccupied
- Net Lab Volume 19,400 ft^3
- Using Equation above: Exhaust Flow = 1940 cfm Occ. & 970 cfm Unocc.

- <u>In this particular lab – these flows are feasible by the equipment serving the lab. **We'll see that this is not always the case!**</u>

Need to Evaluate System Capabilities





Min. Ventilation is a Balance of Limiting Factors

Terminal Device Driven Minimums

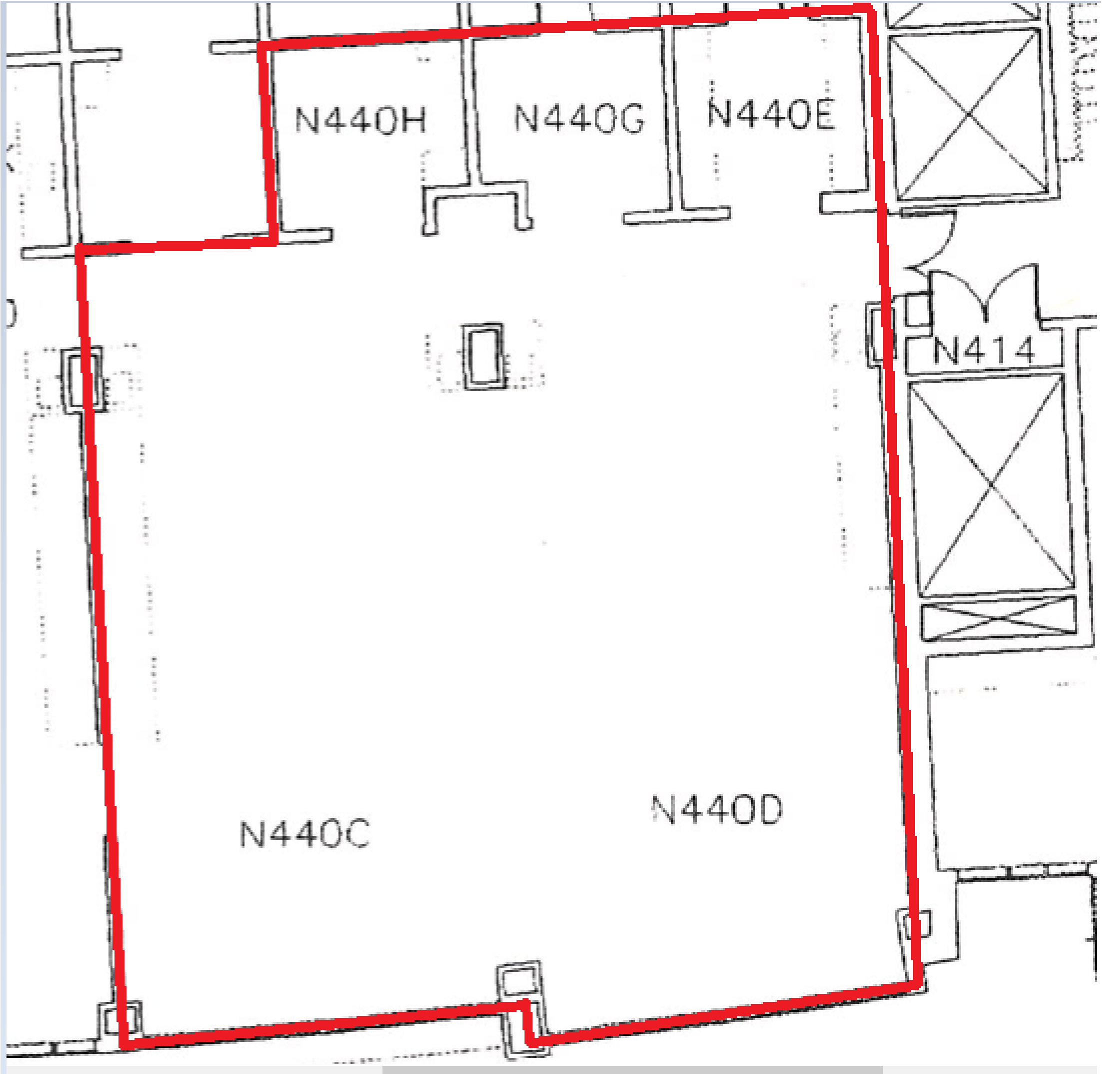
EXAMPLE OF SUPPLY DEVICE LIMITATIONS – SIMPLE, SMALL, LAB		
Room Volume	2240	ft^3
EH&S Approved Unocc. Min	3	ACH
Exhaust Flow @ 3 ACH	112	CFM
Exhaust VAV Manufacturer Minimum	138	CFM
EH&S Required Offset	-150	CFM
Supply Flow @ 3 ACH	-38	CFM
Supply VAV Manufacturer Minimum	75	CFM
Actual Exhaust to comply with Supply and Exhaust VAV Minimums	225	CFM
Resulting ACH @ Higher Flow	6	ACH – **DOUBLE EH&S MIN!**

Limiting Constraint – but not the worst in this lab!

Supply VAV is critical constraint!

Final setpoint satisfies supply & exhaust

Terminal Device Driven Minimums



- 21,000 ft^3
- Approved for 6/3 ACH (Occ/Unocc)
- 4 General Exhaust Devices
- 2 Fume Hoods
- 1 Snorkel Exhaust
- 2 Supply VAVs

- Many factors in this lab zone!

Terminal Device Driven Minimums

Devices	Flows
Exhaust Flow To Achieve 3 ACH Supply Flow To Achieve 3 ACH (+75 offset)	972 CFM 1047 CFM
Supply VAV Manufacturer Minimum	660 CFM **GOOD!**
Fume Hood & Snorkel Minimum Total General Exhaust Min **Total Minimum Exhaust**	335 CFM 804 CFM **1138 CFM**
Resulting ACH	**3.5 ACH**

Can't do anything about this!

- **GEX 1: 12" VAV – 330 CFM Min**
- **GEX 2: 12" VAV – 330 CFM Min**
- **GEX 3: 6" VAV – 72 CFM Min**
- **GEX 4: 6" VAV – 72 CFM Min**

General exhausts 1 & 2 are the constraint! 8" VAVs would be adequate for this application!

Don't Oversize Terminal Devices!

VAV Turndown

- Published = 10%-20%, avg. ~15%
- Reality = 15%-25% **at best**

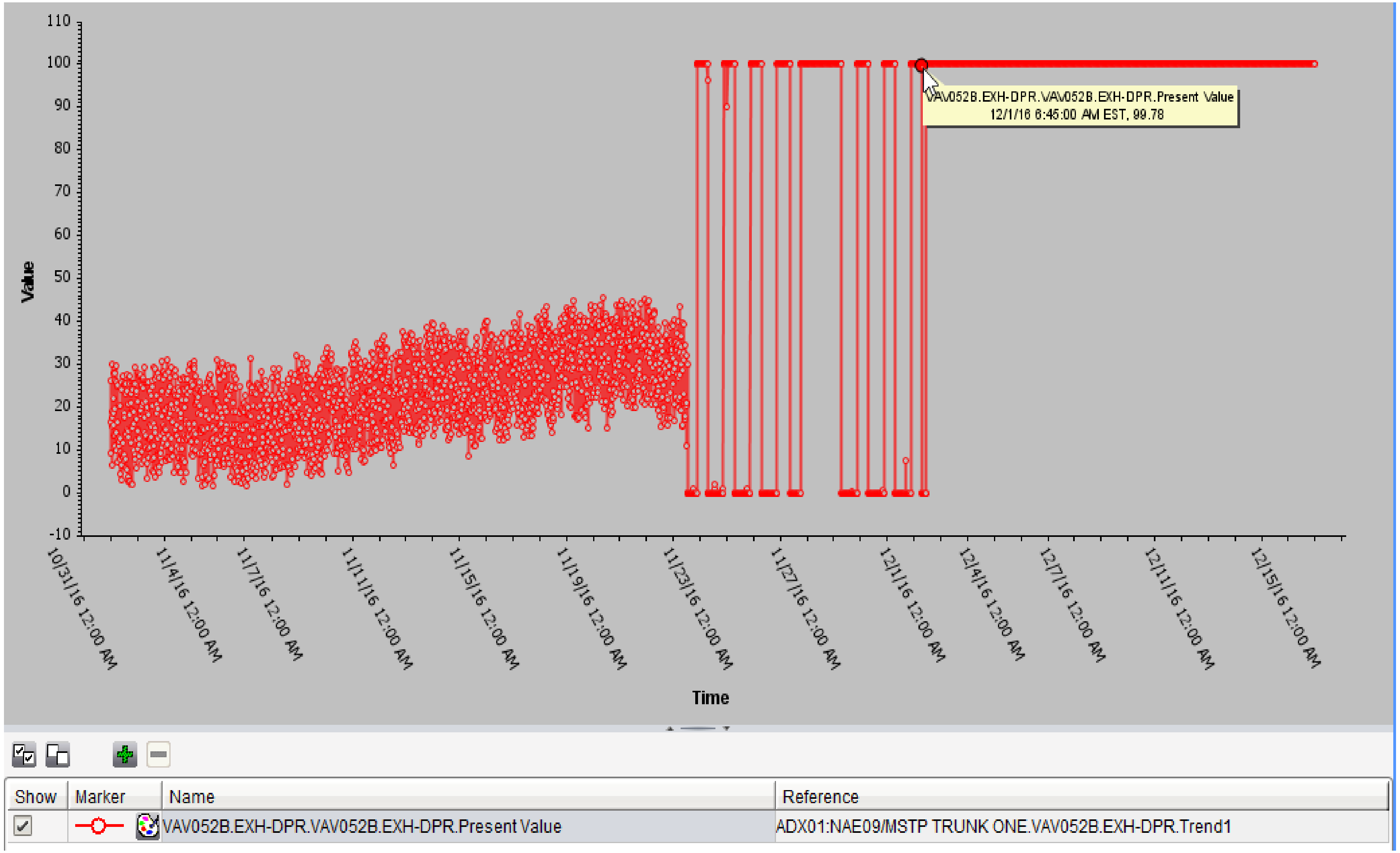
Air Valve Turndown

- Published = 5%-10%
- Reality = Generally as published depending on sizing and pressure drop

Inlet Size	VAV Box				AccuValve			Phoenix Air Valve		
	Published Mfr. Min	Device Max	Pub. Turn-down	Safe Turn-down	Published Mfr. Min	Device Max	Turn-down	Published Mfr. Min	Device Max	Turn-down
6	65	550	12%	15%-25%	30	315	10%			
8	125	1,100	11%	15%-25%	80	800	10%	35	700	5%
10	210	1,800	12%	15%-25%	120	1,300	9%	50	1,000	5%
12	300	2,600	12%	15%-25%	180	1,800	10%	90	1,500	6%
14	390	3,700	11%	15%-25%	250	2,750	9%	200	2,500	8%

- Consider these differences when designing new facilities – there are lasting cost implications to oversizing equipment

Pitfalls With Terminal Devices



- Trying to control a terminal device below it's manufacturer recommended minimum can cause severe hunting.
- Hunting VAV caused actuator to fail.
- Could cause lab pressurization & safety issues.

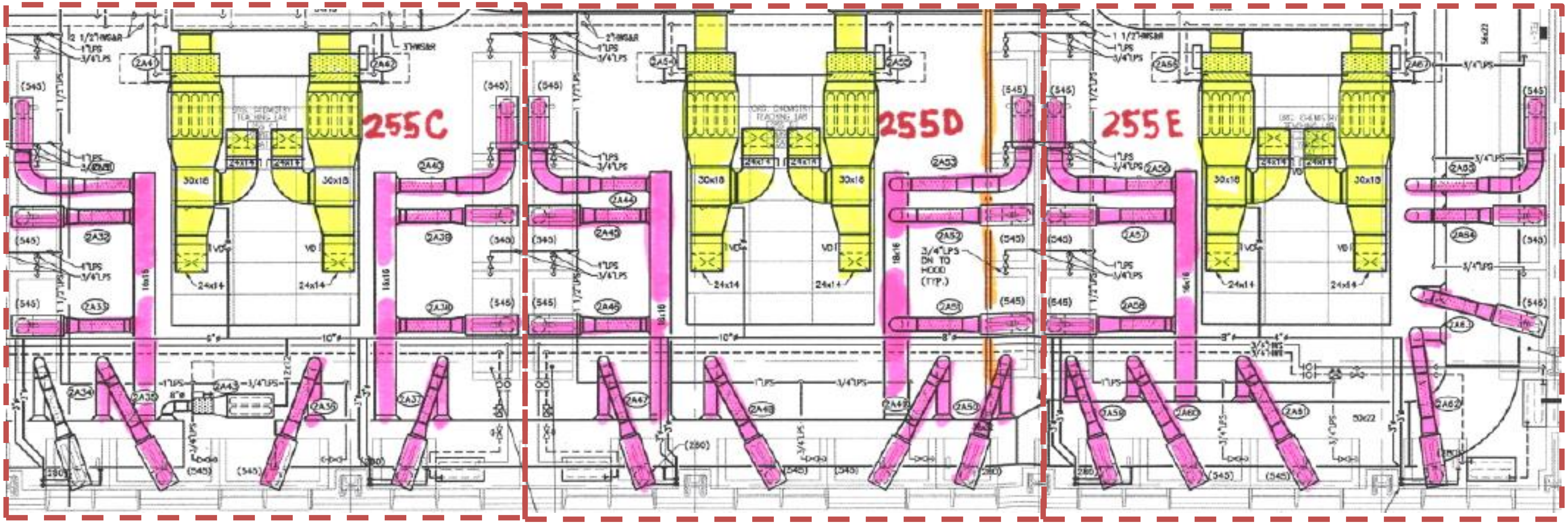
Pitfalls With Terminal Devices

- Flow measurement accuracy can suffer when terminal devices operate near their minimums and measurements can drift from original TAB calibration

		Original K-Factor		New K-Factor	
		TAB Reading	Metasys Reading	TAB Reading	Metasys Reading
General Exhaust Flow	cfm	3,681	4,065	4,018	4,027
Total Fume Hood Flow	cfm	200	200	200	200
Total Supply Flow	cfm	4,091	3,786	3,696	3,751
Offset Setpoint	cfm	-500		-500	
Actual Measured Offset	**cfm**	**210**	**-479**	**-522**	**-476**

- A K-Factor (or pickup gain) relates pressure velocity and area to airflow in VAVs (and other flow applications)

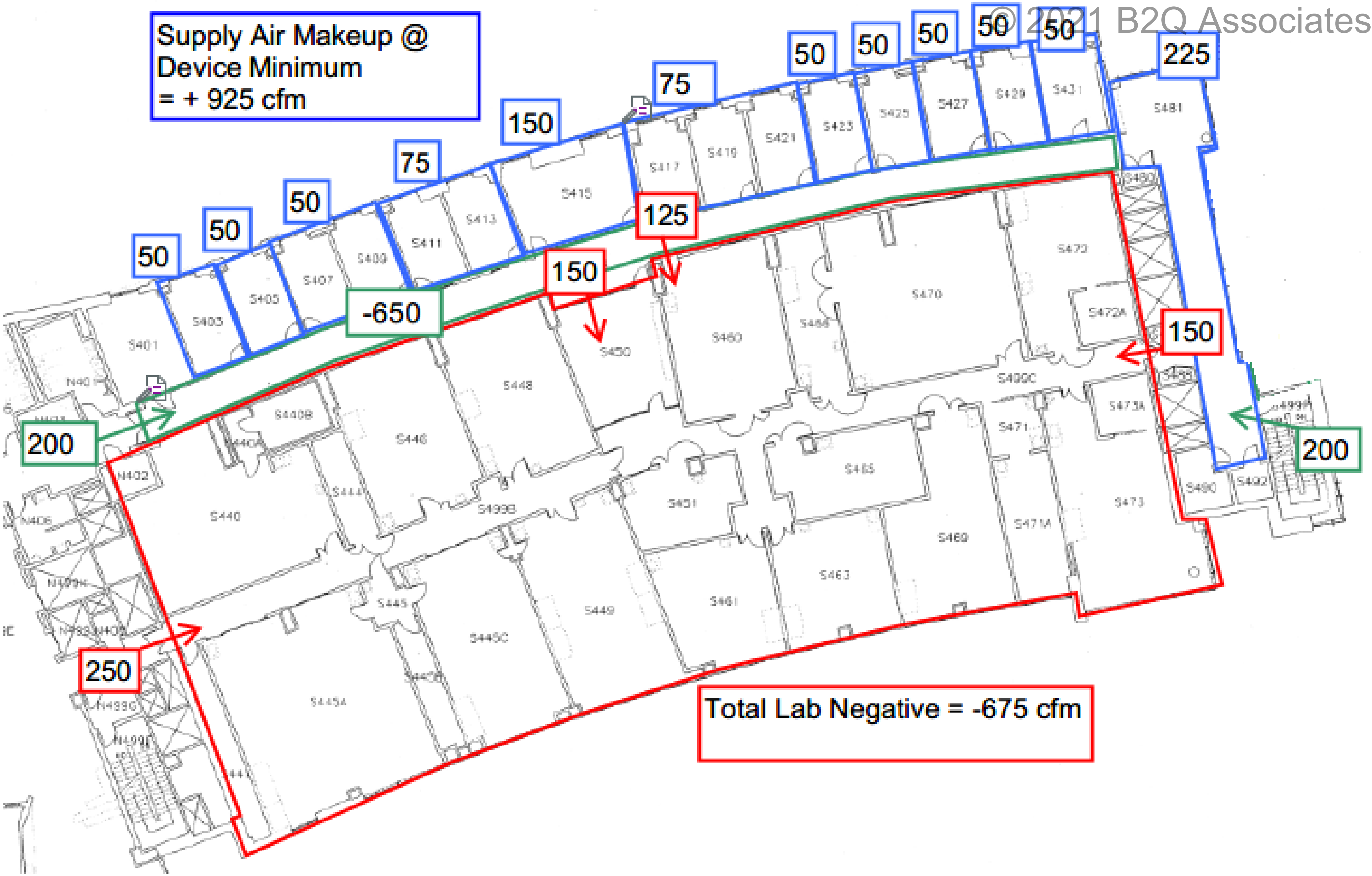
Fume Hood Driven Zones



- Each lab in this floor plan has 10 fume hoods
- Even with sashes closed – flow is well above EH&S approved minimums!
- Thankfully no GEX in this zone – but if there was, total lab exhaust would increase

Lab Devices aren't the only thing to Consider!

Non-lab Makeup air can impact lab ventilation.



With all these limiting factors – can you still have a successful RCx Lab Project?

• **Integrated Sciences Building** • 8 years old • 150,000 ft^2 (85,000 ft^2 of Lab Space) • **4,620,580 kWh - Baseline** • **29,000 MLbs Steam - Baseline** • **<u>$1,042,058 </u>in Energy** Annually – Baseline • EUI: 275 kBtu/ft^2 – Baseline (2015)	• **Engineering Lab II (ELab II)** • 13 years old • 61,000 ft^2 (21,474 ft^2 of Lab Space) • **2,636,348 kWh - Baseline** • **15,096 MLbs Steam - Baseline** • **<u>$565,554</u> in Energy Annually – Baseline** • EUI: 359 kBtu/ft^2 – Baseline (2015)	• **Life Science Labs North & South** • 4/2 years old (N./S.) • 310,000 ft^2 (50% labs) • **7,432,504 kWh - Baseline** • **24,580 MLbs Steam - Baseline** • **<u>$1,234,850</u> in Energy Annually – Baseline** • EUI: 240 kBtu/ft^2 – Baseline (2016)

- **Baseline Totals: 14.5 Million kWh | 68,500 mlbs steam | $2.8 Annually**

OF COURSE!

Building	Total Electric Energy Savings	Steam Energy Savings	Energy Cost Savings	Project Cost	Simple Payback
--	kWh	Mlb	$	$	yrs.
ISB	1,851,862	10,738	$399,946	$590,968	1.5
Elab II	677,294	6,312	$193,968	$448,907	2.3
LSL North	900,000	1,340	$116,800	$502,000	4.3
LSL South - Predicted	469,000	2,860	$104,100	$259,174	2.5
Totals	**3,898,156**	**21,250**	**$814,814**	**$1,801,049**	**2.2**
% Due to Vent. Opt.	**67%**	**44%**			

- End result are buildings with labs that are, **SAFE**, operate in an efficient, sustainable manner and have ventilation that takes all factors into account

Concluding Thoughts

- Just because "Someone" – EH&S, Consultant, Rep… says a low ACH is feasible doesn't mean the building and systems are capable of this performance

- When evaluating ventilation reductions:
  - Understand lab risk – consult EH&S or CIH
  - Take capabilities of lab airflow devices into account
  - Take "whole floor" into consideration – factors outside the lab can impact ventilation inside the lab

- Don't trust the BAS – Contract a Testing, Adjusting and Balancing Contractor!

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Questions?