# 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. Understand potential pitfalls in RCx that can occur if constraints are not taken into account

# 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

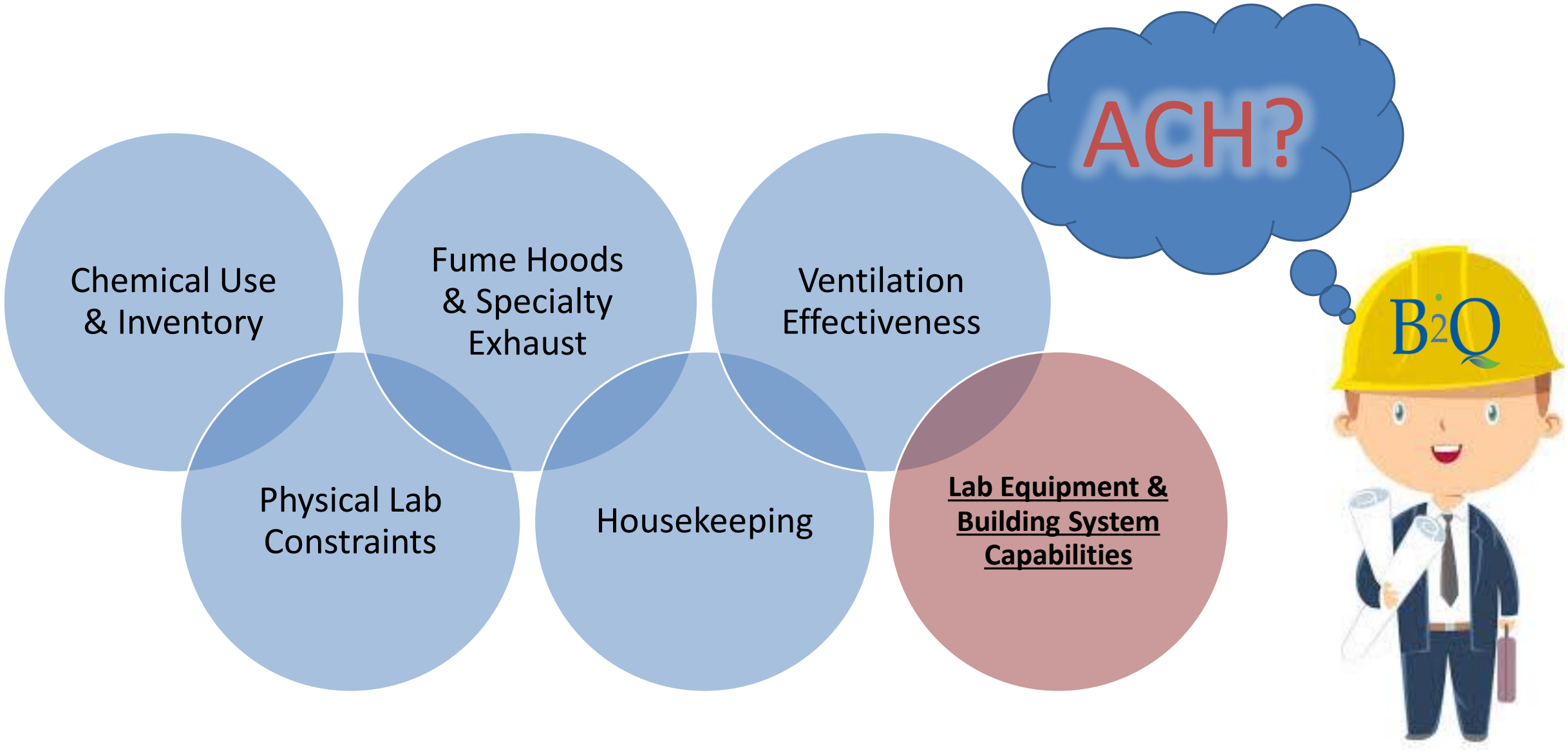
- Need to evaluate the current use of labs, examine existing equipment and ensure the labs and building operate to meet the current use.

# 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. **<u>Evaluate lab system and equipment capabilities</u>**
   - 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

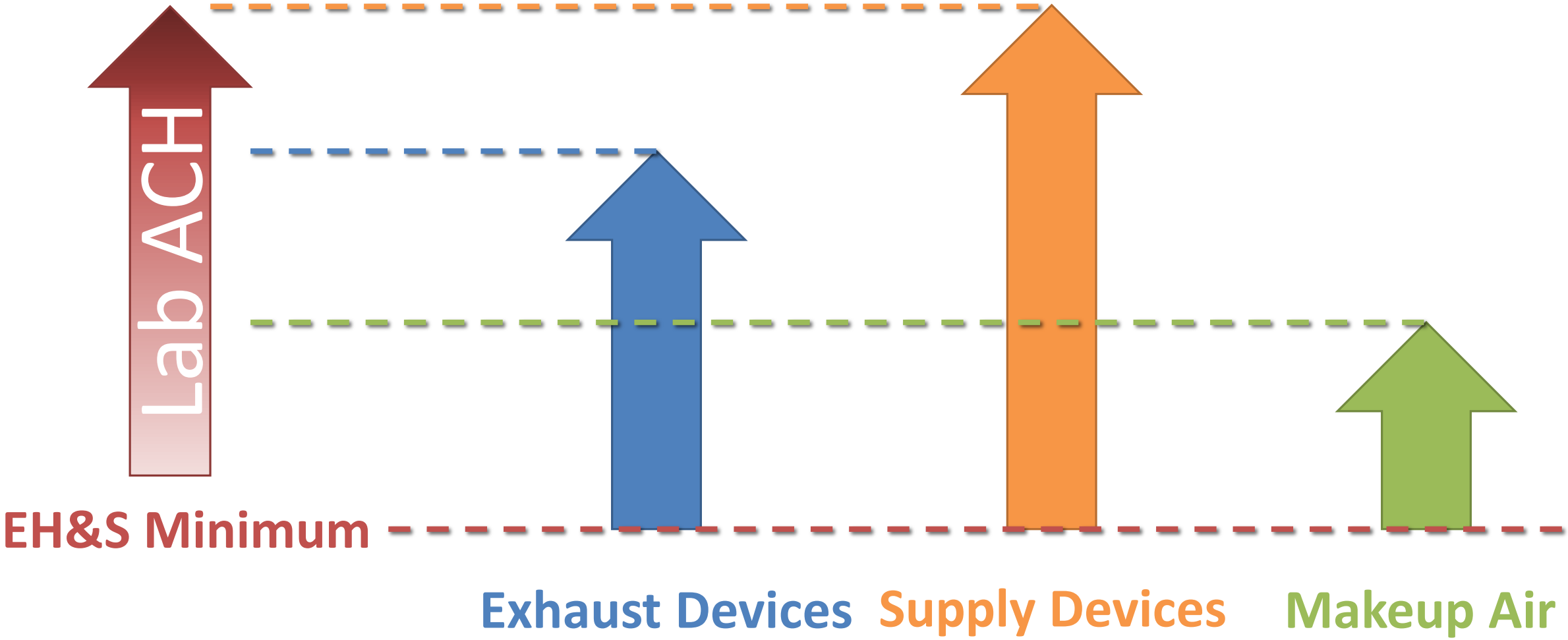
$$Total\ Exhaust\ Airflow\ \left(\frac{ft^3}{min}\right) = \frac{Air\ Change\ Rate\ (ACH)\ x\ Net\ Lab\ Volume(ft^3)}{60\frac{min}{hour}}$$

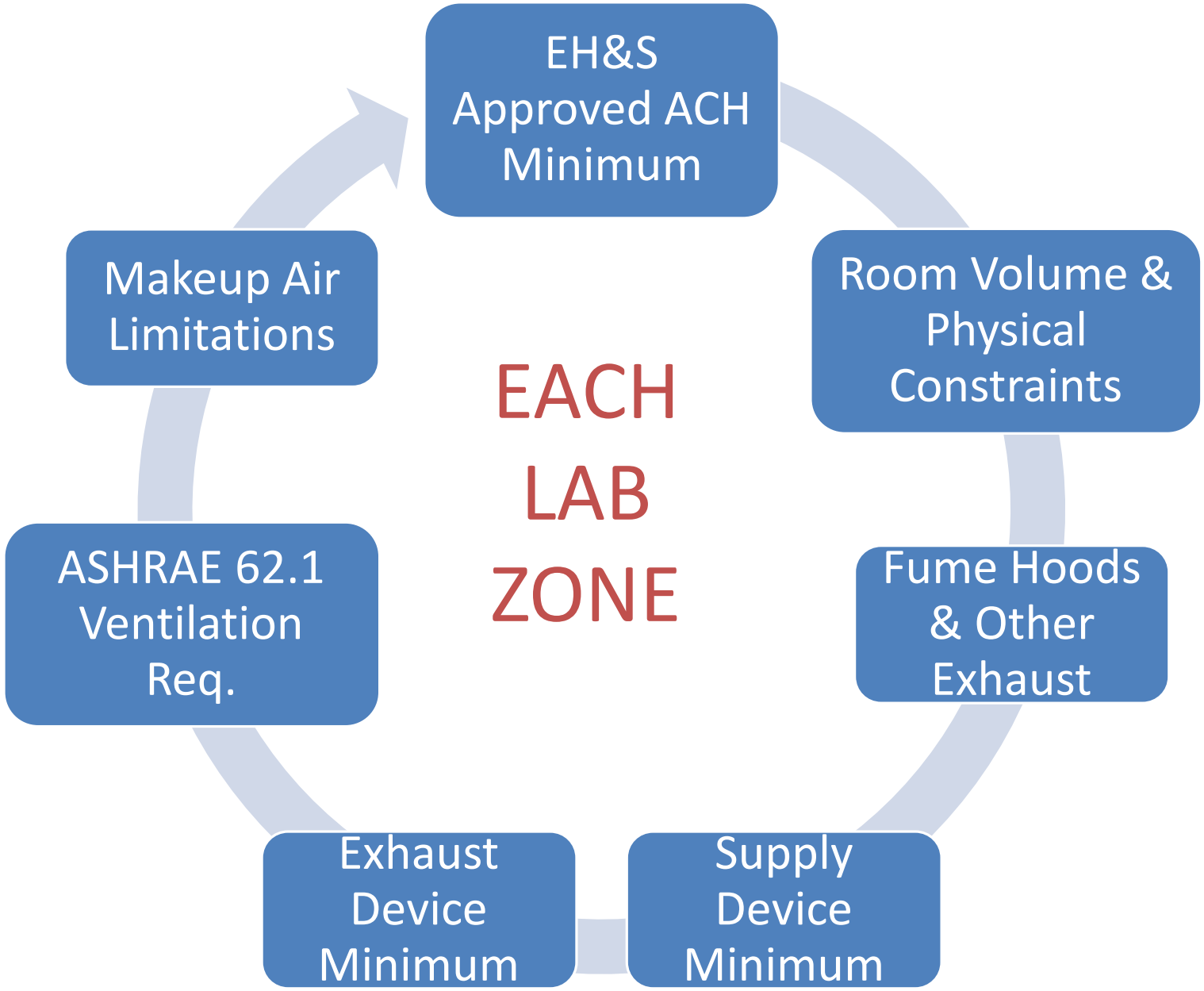
**Lowest Possible Total Lab Exhaust to Meet EH&S Requirements**

- 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.

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

# Need to Evaluate System Capabilities






# Min. Ventilation is a Balance of Limiting Factors

# Terminal Device Driven Minimums

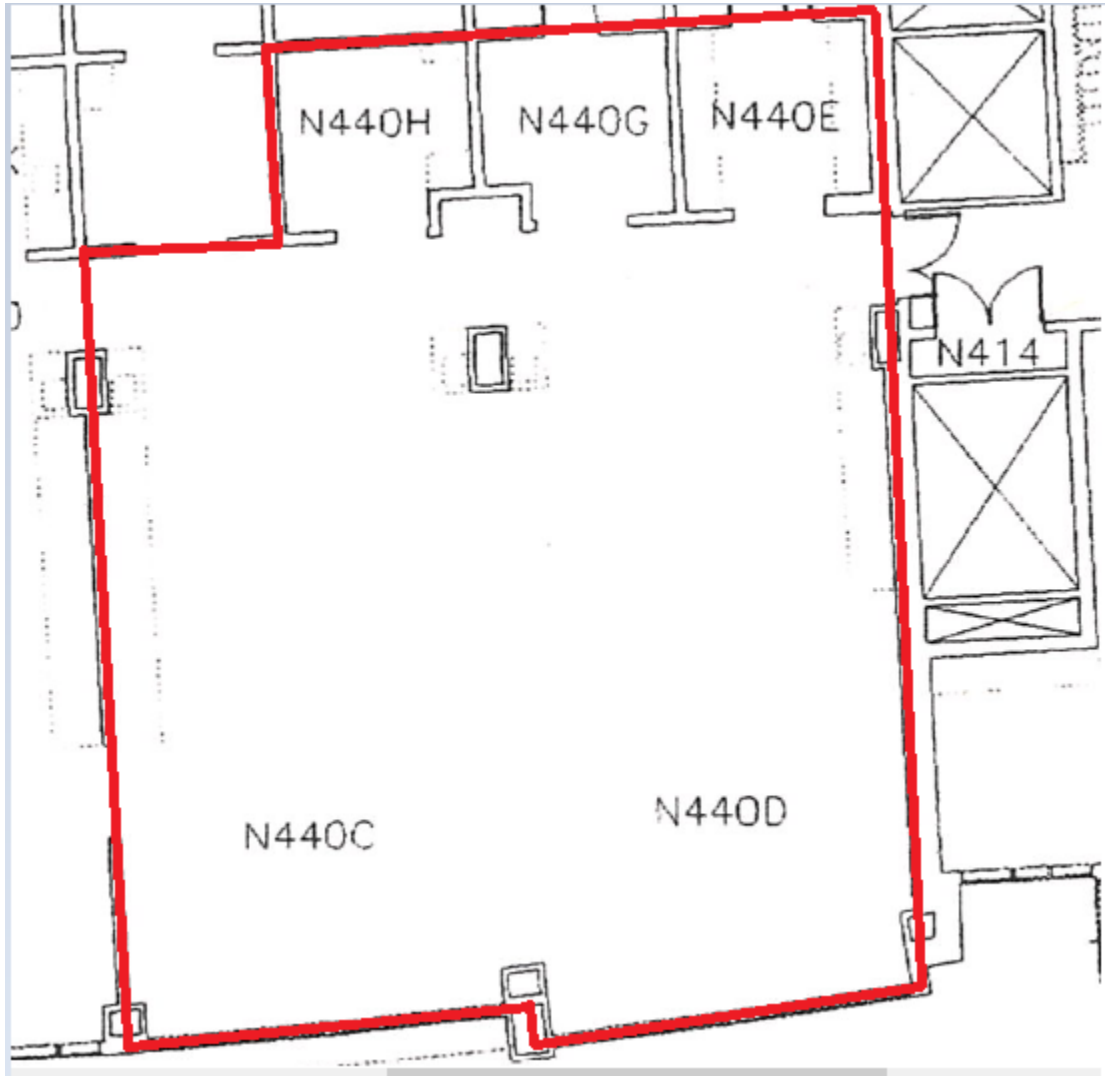
| EXAMPLE OF SUPPLY DEVICE LIMITATIONS – SIMPLE, SMALL, LAB | | |
|---|---|---|
| Room Volume | 2240 | $ft^3$ |
| EH&S Approved Unocc. Min | 3 | ACH |
| Exhaust Flow @ 3 ACH | 112 | CFM |
| Exhaust VAV Manufacturer Minimum | 138 | CFM |
| EH&S Required Offset | -150 | CFM |
| Supply Flow @ 3 ACH | -38 | 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<br>Supply Flow To Achieve 3 ACH (+75 offset) | 972 CFM<br>1047 CFM |
| Supply VAV Manufacturer Minimum | 660 CFM GOOD! |
| Fume Hood & Snorkel Minimum<br>Total General Exhaust Min<br>**Total Minimum Exhaust** | 335 CFM<br>804 CFM<br>**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**

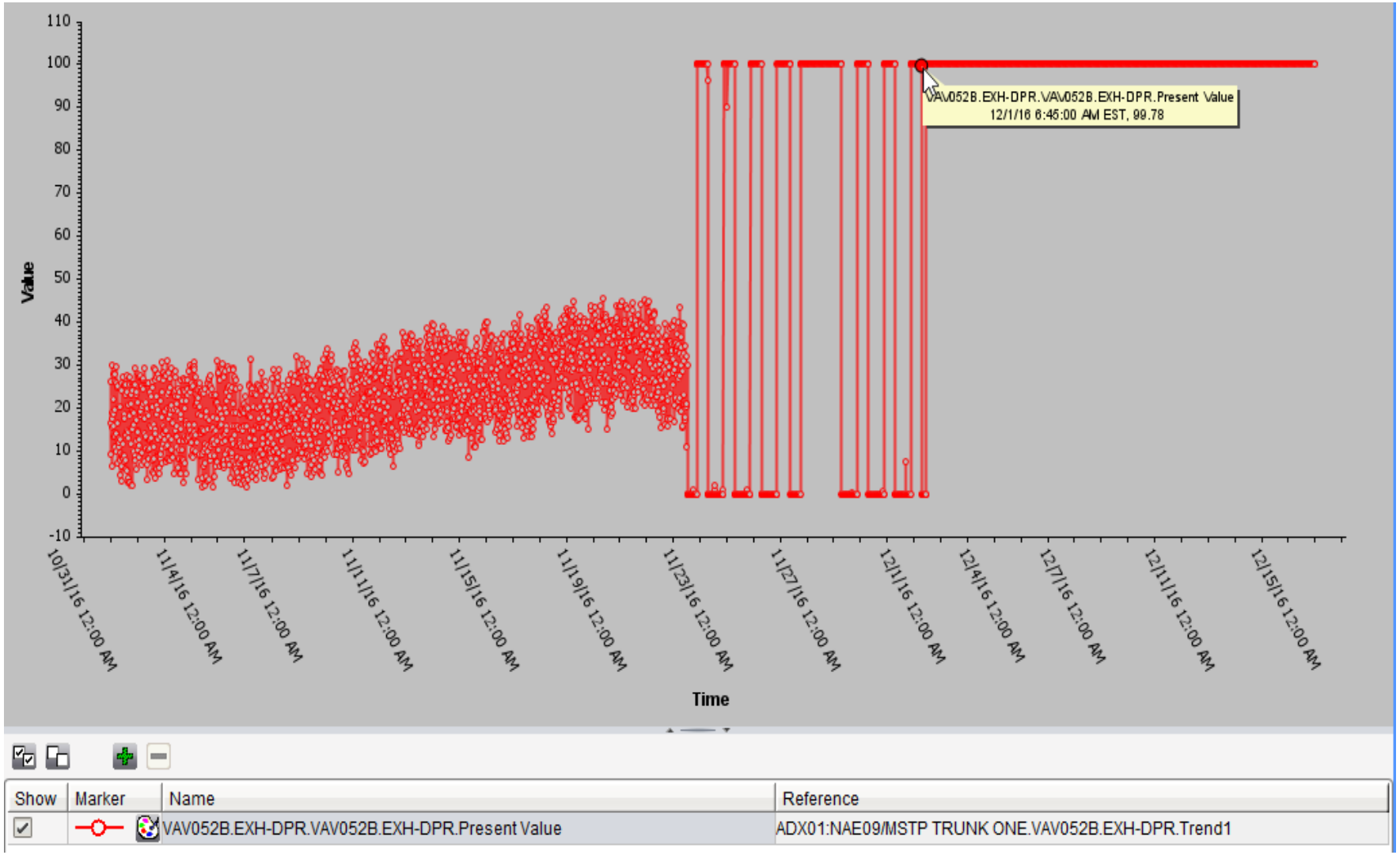
## Air Valve Turndown

- 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.

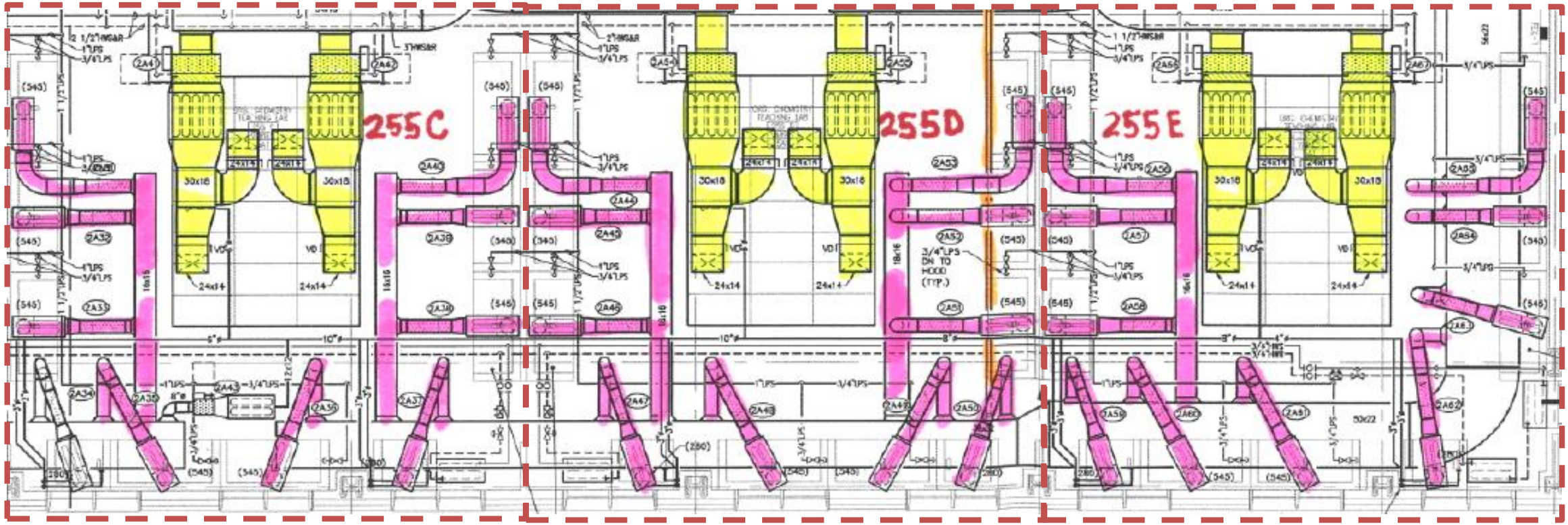
# Pitfalls With Terminal Devices

- 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)

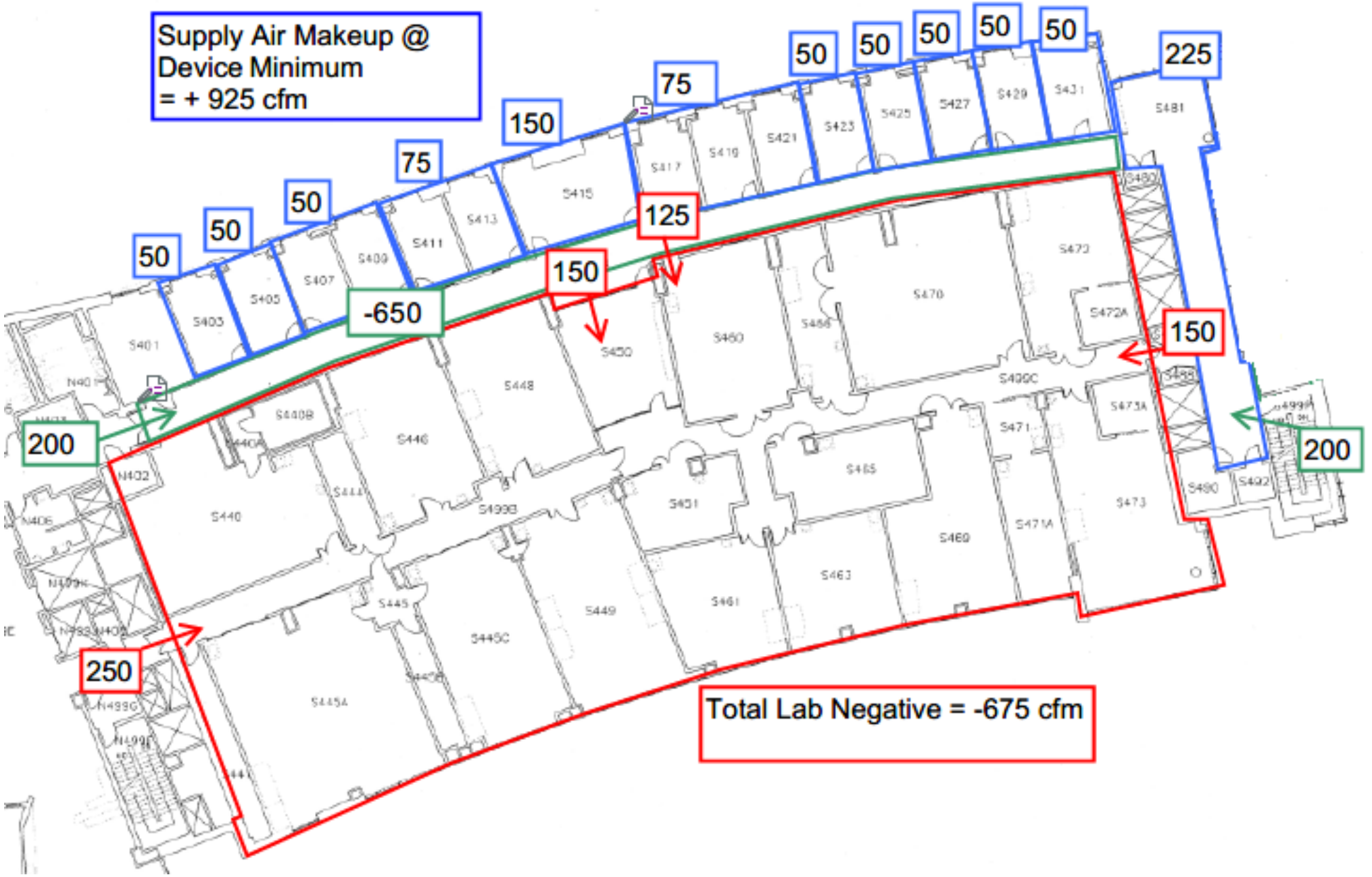
# Fume Hood Driven Zones




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

# Questions?

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