

BCxA TechTalks



TechTalks – Delivered by Members for Members

Air Flow Reduction in a Large Research Building



Rod Rabold, CxA Senior Cx Engineer
University of NC - Chapel Hill



Medical Biomolecular Research Building (MBRB)

Opened in 2003 for the UNC-CH School of Medicine



Project Background

Project Size

Building Size – 222,200 gross sq. ft.

Spaces include;

- Labs - 55,550 sq. ft. (2 AHUs – designed 100,000 cfm ea.)
- Offices - 24,900 sq. ft. (1 AHU – designed 33,000 cfm)
- Vivarium - 12,500 sq. ft. (1 AHU – 44,000 cfm)
- Auditoriums, atrium, mechanical rooms, other assigned spaces (3 AHUs – total 32,000 cfm)

MBRB

Interior Building Spaces



Two auditoriums, 274 and 492 seats



4 story atrium

MBRB

Interior Building Spaces



Open Lab Bay - 4 to 6 Bays
per open lab



Single Room Labs

MBRB

Interior Building Spaces



Sensitive BSL 2 and 3 Labs



Areas of concentrated heat loads

Project Background

History

- MBRB was part of a UNC-CH campus wide proposed energy performance contract.
- After completion of the investment grade audit (IGA) UNC-CH decided to self perform the energy improvements versus using an ESCO.
- UNC advertised for a designer and selected Dewberry Engineers (Raleigh, NC office).

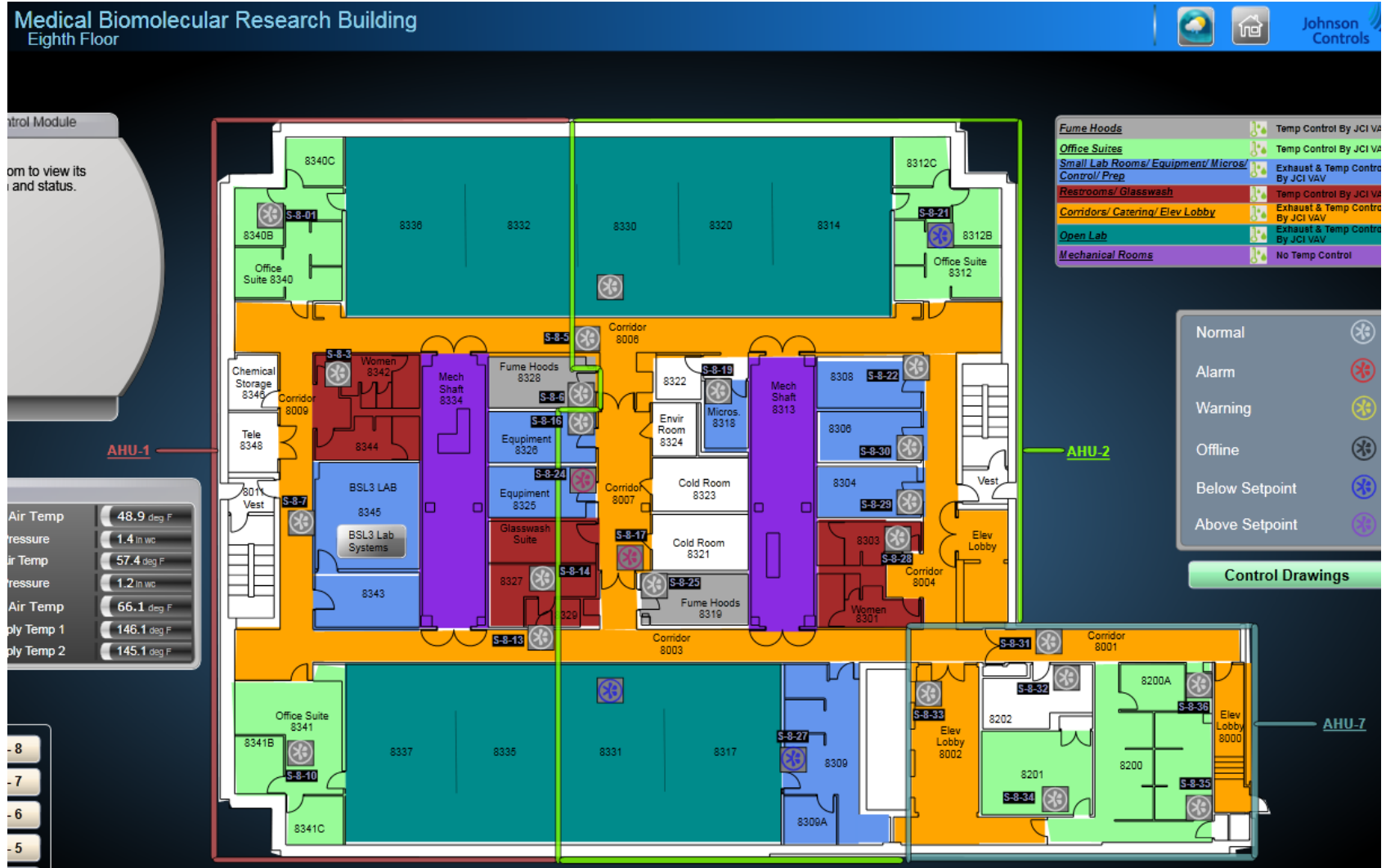
Unique Design Features of MBRB

- The lab Air Changes per Hour (ACH) rate was around 12 ACH or higher.
- Terminals were pneumatically controlled Nailor opposed blade terminals.
- Each CV fume hood has a dedicated exhaust fan, hard balanced (no FH exhaust terminal).
- ‘Future’ installed fume hood exhaust fans provided part of the general exhaust of the open labs.

Unique Design Features of MBRB

- Lab office supply air flows are designed to provide make up air flow to the labs.
- Each floor has 2 large open labs of 3 to 5 bays, with varying number of supply and exhaust terminals and fumehoods.

Typical Floor Plan



Project Background

Goals & Objectives (OPR)

- Energy Conservation Measures
 - Reduce Lab Airflows (ACH)
 - Convert from Constant to Variable Volume terminal control
- Controls Upgrades
 - Extend DDC controls to all terminal units (Supply & Exhaust)
 - 353 terminal unit controls upgraded
- Maintain Occupied Building
 - Minimize disruptions to the occupants during the project

Scope of Work

ECM - Airflow Reductions

Determine the ACH Minimum

- General lab ventilation ACH requirement
 - 6 ACH Minimum allowed by UNC-CH EHS
- Cooling Load (& Heating)
 - Equipment Rooms / Corridors
 - Corner Office Spaces
- Makeup Air
 - Ensure building pressurization is positive

Scope of Work

Issues Addressed

- Overall Building Pressurization (Negative)
- Office terminal noise & comfort
- Thermostat locations
- Hot spots in core
- Open lab environment & control



Scope of Work

Implementation

- BAS Control Submittal meeting
- Communicated Project Schedule
 - Occupied building required good communication between contractors & occupants.
- 3 zones (~rooms) at a time
 - Must notify occupant if schedule changes.
- Strategy
 - Started with groups on lower floors (near AHU) and worked our way to the upper floors (end of duct) to optimize dP.
 - BSL-3 Lab Considerations – No AHU shutdowns or work in adjacent areas without 2 week notice.

Open Lab Controls

- For lab controls on this project the open labs were considered one zone versus sub sections or bays. Some labs have a different number of general supply and exhaust terminals.
- The open labs are designed negative to the hallway so the supply air flow tracks exhaust air flow with a flow offset.

Open Lab Controls – Air Flow

- As cooling load increases the exhaust flow setpoint is increased from 0 to 100%, the % cooling signal commands each general exhaust terminal from the min to max of the scheduled flow.
- When the status of a FH exhaust fan is ON, an assigned TAB exhaust flow is used in the total lab exhaust flow calculation.
- Supply terminals cfm sum track (=) the total lab exhaust cfm sum, minus (-) a flow offset. A 0 to 100% supply tracking command is sent to each supply terminal, to increase flow from the min to max of scheduled flow of each terminal.

Open Lab Controls – Air Flow

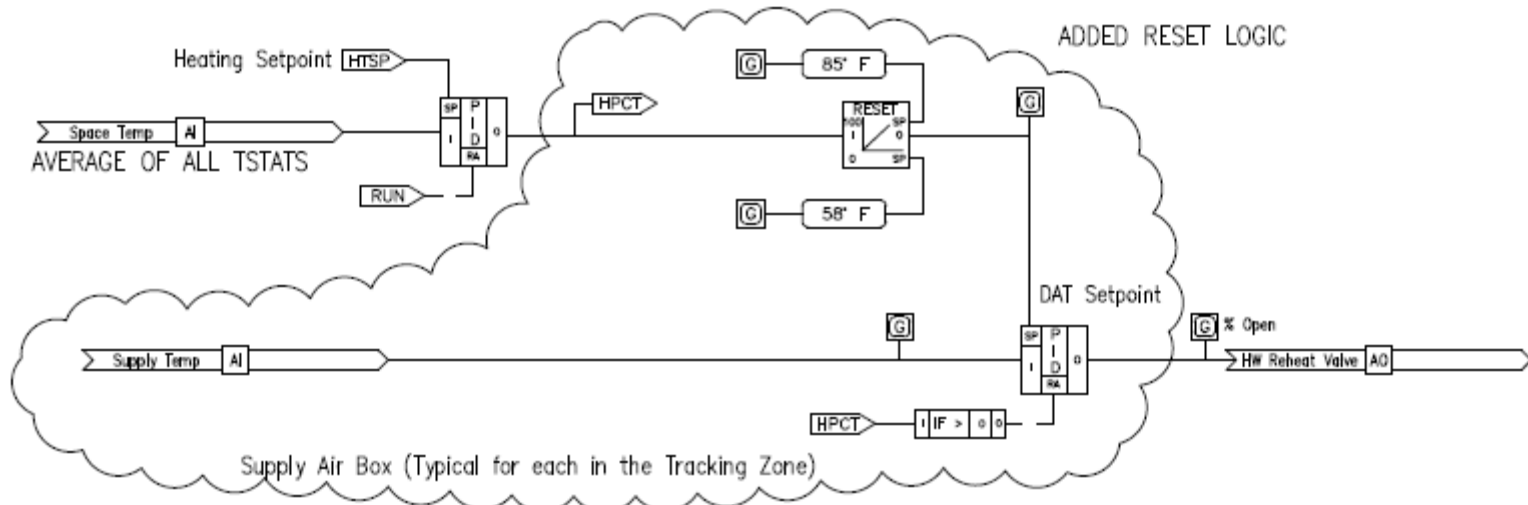
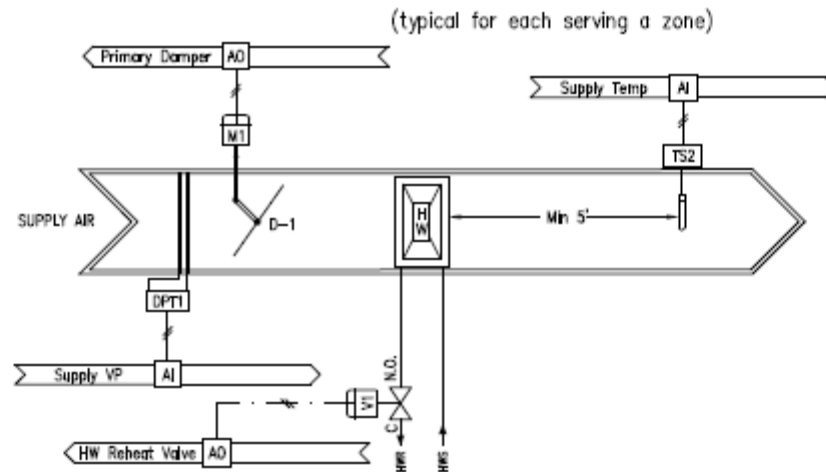
In a failure mode

- If lab exhaust systems shut down the supply terminal command reduces CFM accordingly to track exhaust CFM to prevent a positive lab.
- If AHUs systems shut down the general exhaust systems are shut down for egress purposes.

Open Lab Controls – Temperature Options

- A. Have each supply terminal control to a dedicated t-stat.
Downside - this can result in terminals simultaneously heating and cooling.
- B. Have the BAS average all t-stats and provide an averaged temperature. Compare average temp to a heating setpoint and provide a common heating % PID output to all terminals.
Downside - hot water valves at the same % stroke can provide different DATs from terminals.
- C. Send the common heating % PID output to a temp reset block to provide a common DAT setpoint. Use each terminal's DAT and compare to the common DAT SP, command each reheat control valve to maintain DAT setpoint.

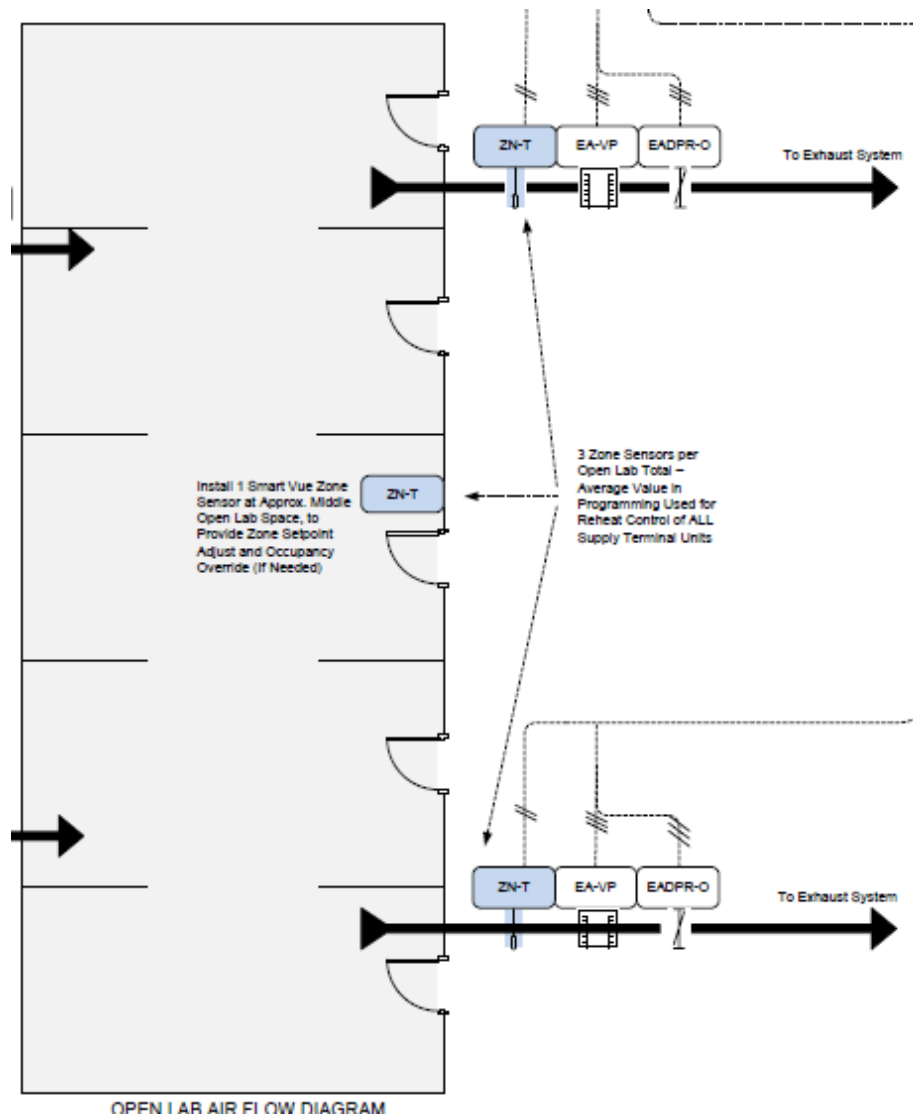
Open Lab Temperature Logic



Lab Controls - Temperature

- T-Stat locations can not always be located away from heat sources or from being blocked by obstacles (Cx 101).
- To address this issue on this project, one master t-stat was installed on the wall with adjustment and occupancy override, and 2 temperature sensors were installed in the exhaust ducts.

Lab Controls – Temp Sensor Location



Open Lab Temperature Control

LAB TEMPERATURE DATA

Avg Zone Temp	73.1 deg F
E-5-1 Exhaust Temp	73.8 deg F
E-5-13 Exhaust Temp	73.1 deg F
Zone Sensor Temp	72.4 deg F
Zone Setpoint	73.0 deg F
Zone Sensor Stpt Adj	2.0 deg F
Eff Cooling Setpoint	77.0 deg F
Eff Heating Setpoint	73.0 deg F

Note zone and exhaust temps with average temp used for control

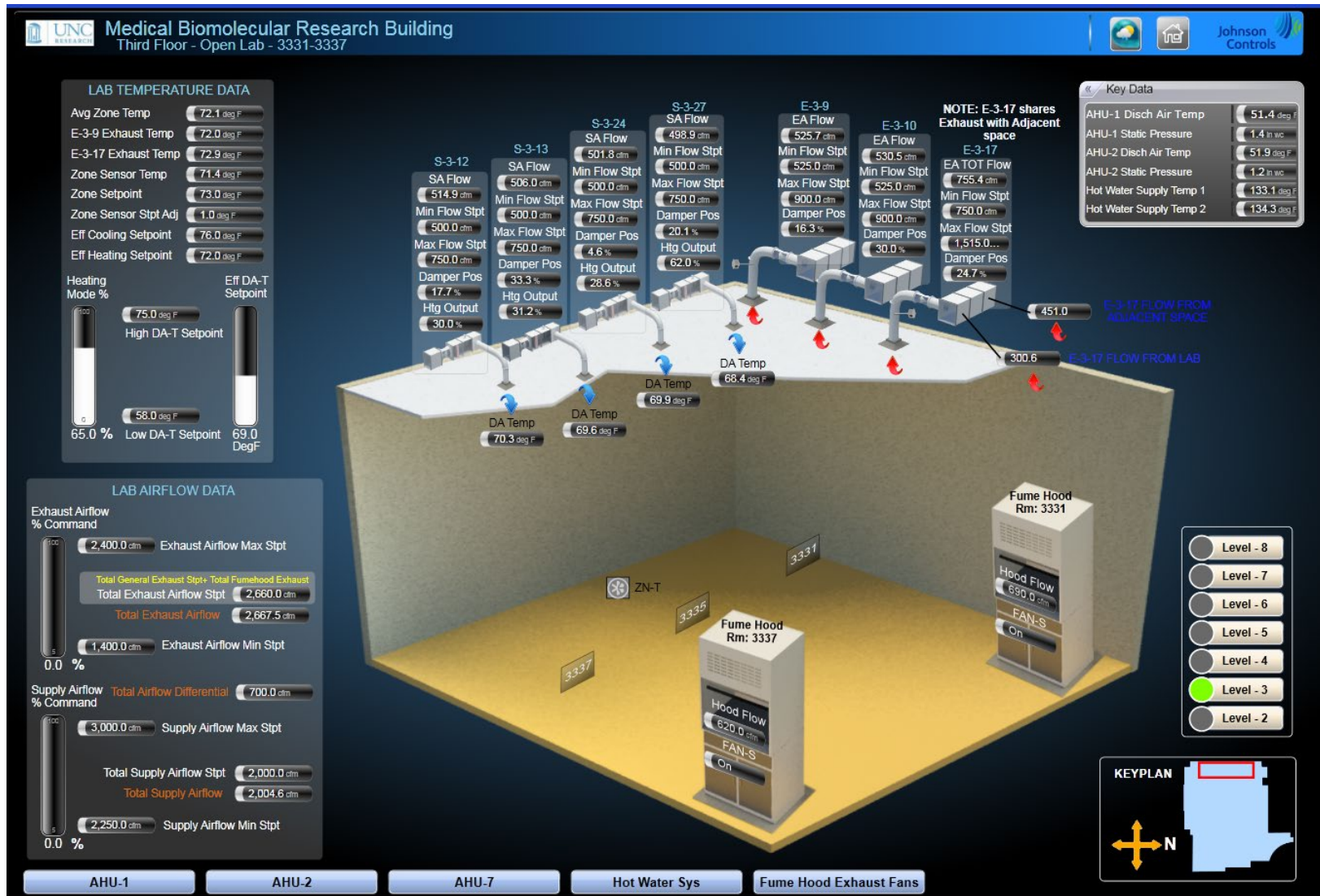
Note valve Htg command outputs and DATs for the 5 supply terminals

Zone Sensor Stpt Adj: 2.0 deg F
Eff Cooling Setpoint: 77.0 deg F
Eff Heating Setpoint: 73.0 deg F

Heating Mode %: 77.3 %
High DA-T Setpoint: 75.0 deg F
Low DA-T Setpoint: 58.0 deg F
Eff DA-T Setpoint: 71.2 DegF

Terminal	Min Flow Stpt	Max Flow Stpt	Damper Pos	Htg Output	DA Temp
1	665.1 cfm	580.0 cfm	32.3 %	21.4 %	71.8 deg F
2	580.0 cfm	870.0 cfm	22.3 %	22.5 %	71.2 deg F
3	870.0 cfm	870.0 cfm	23.3 %	26.7 %	71.1 deg F
4	870.0 cfm	870.0 cfm	22.5 %	22.5 %	71.2 deg F
5	870.0 cfm	870.0 cfm	22.3 %	22.5 %	71.5 deg F

BAS Open Lab Graphics



Project Challenges

Conditions & Air Flow

- Terminal HW reheat valve replacement

Valve unions difficult to disassemble, after breaking a few coil piping connections had a meeting with the contractor to discuss proper technique to prevent further coil damage.

- Terminal airflow DP sensor – Range & Accuracy

Monitored terminal airflow DP sensors to ensure the sensor range was adequate given that the terminal unit had new lower flow and pressures.

Project Challenges

Replacing old HW Reheat valves



Project Results

Fume Hood (FH) Exhaust Fan Operations Reduced



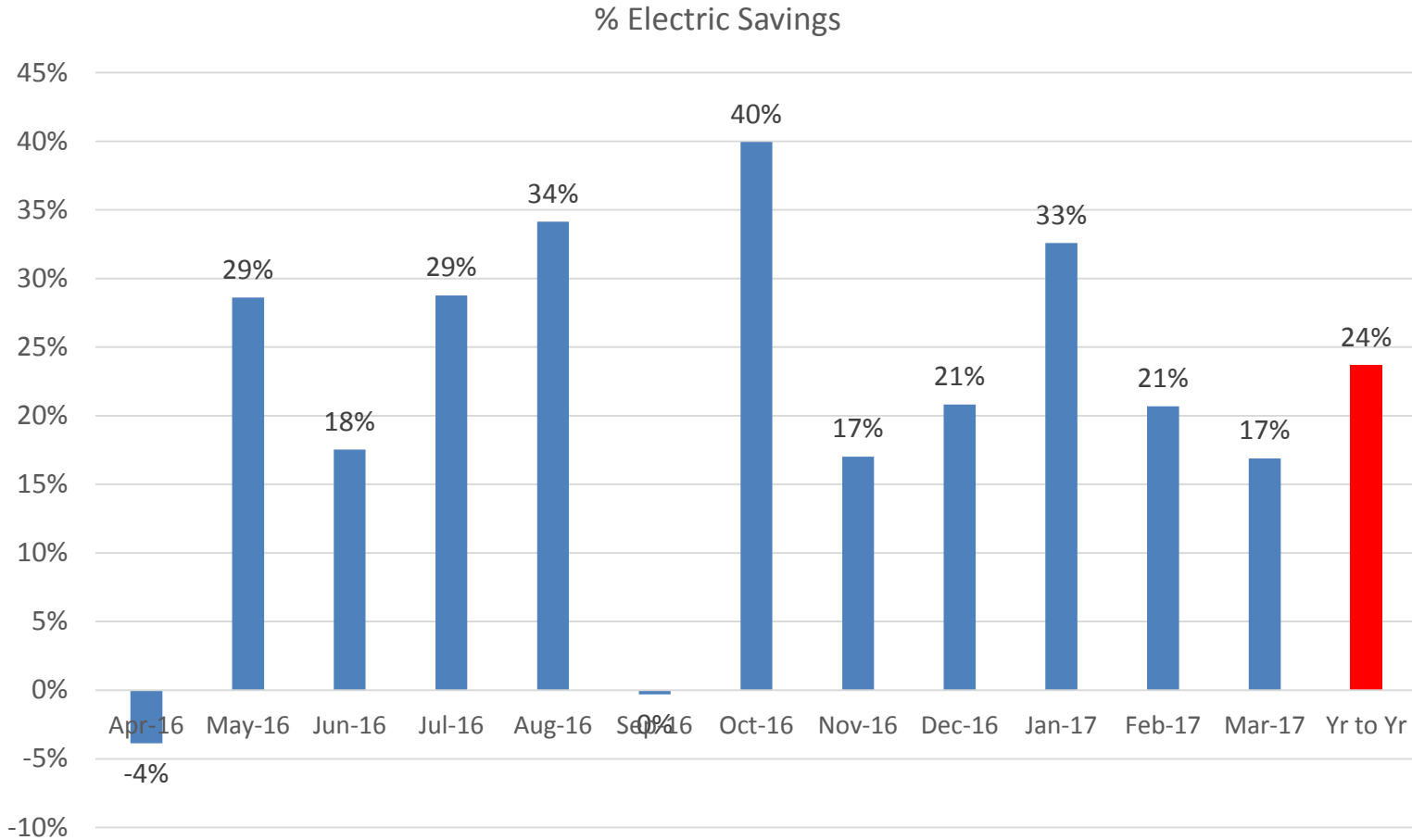
- Some FH exhaust fans were designed for future FHs, and were being used for general exhaust purposes.
- FH exhaust fans used as general exhaust were turned off and tagged out, the general exhaust system now provides all lab general exhaust.
- 36 FH exhaust fans taken out of service

Cx Findings Included

- Found incorrect duct static pressure calibrations, 0-5.0” transmitter scaled for 0-2.5” on AHUs and General Exhaust systems, resulting in much higher operating static pressures, energy usage and terminal control issues. (The AHUs were Cx in another project after this was complete.)
- Cx issues log documented 94 items which were addressed.

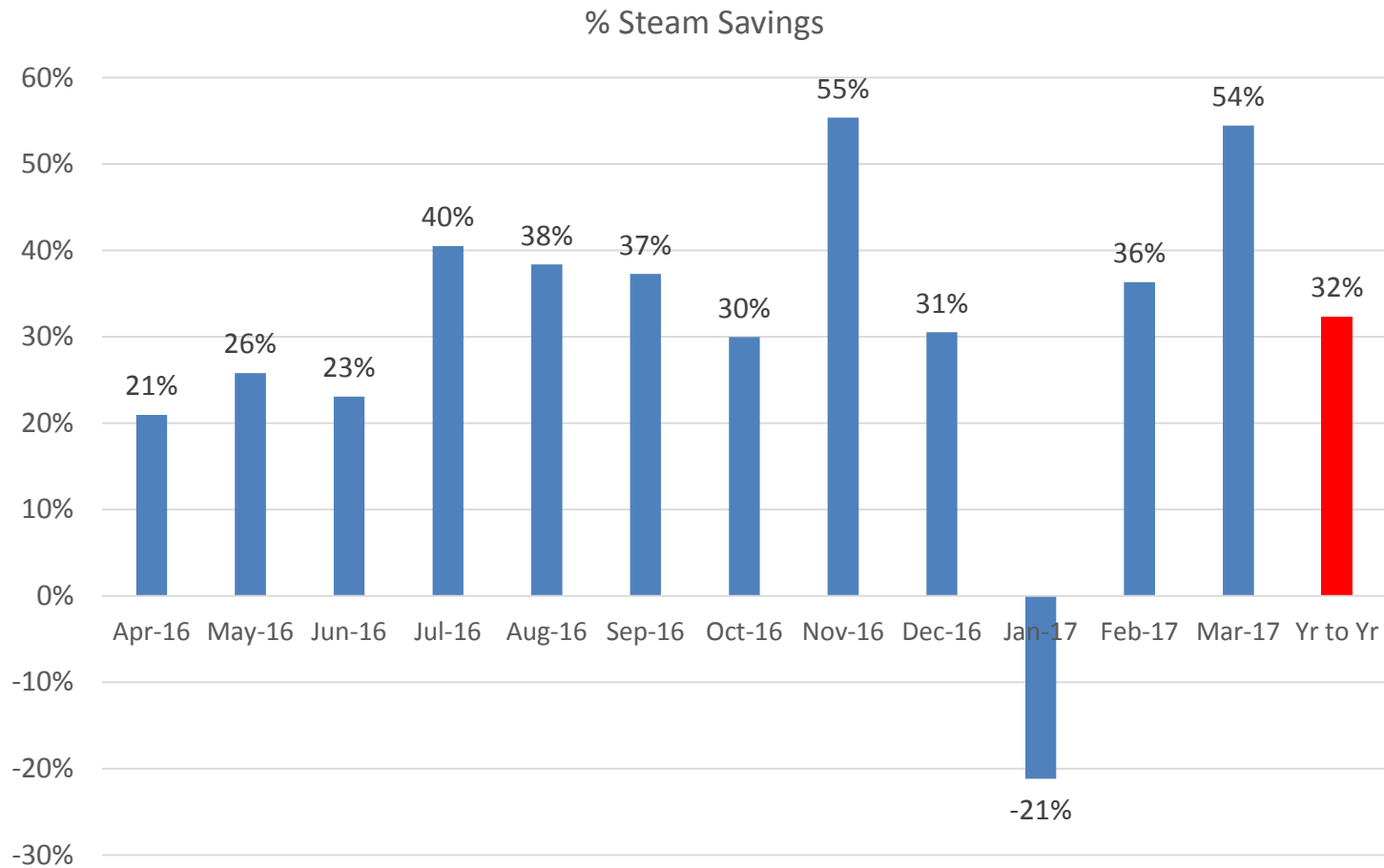
Project Results

Electrical – % Savings



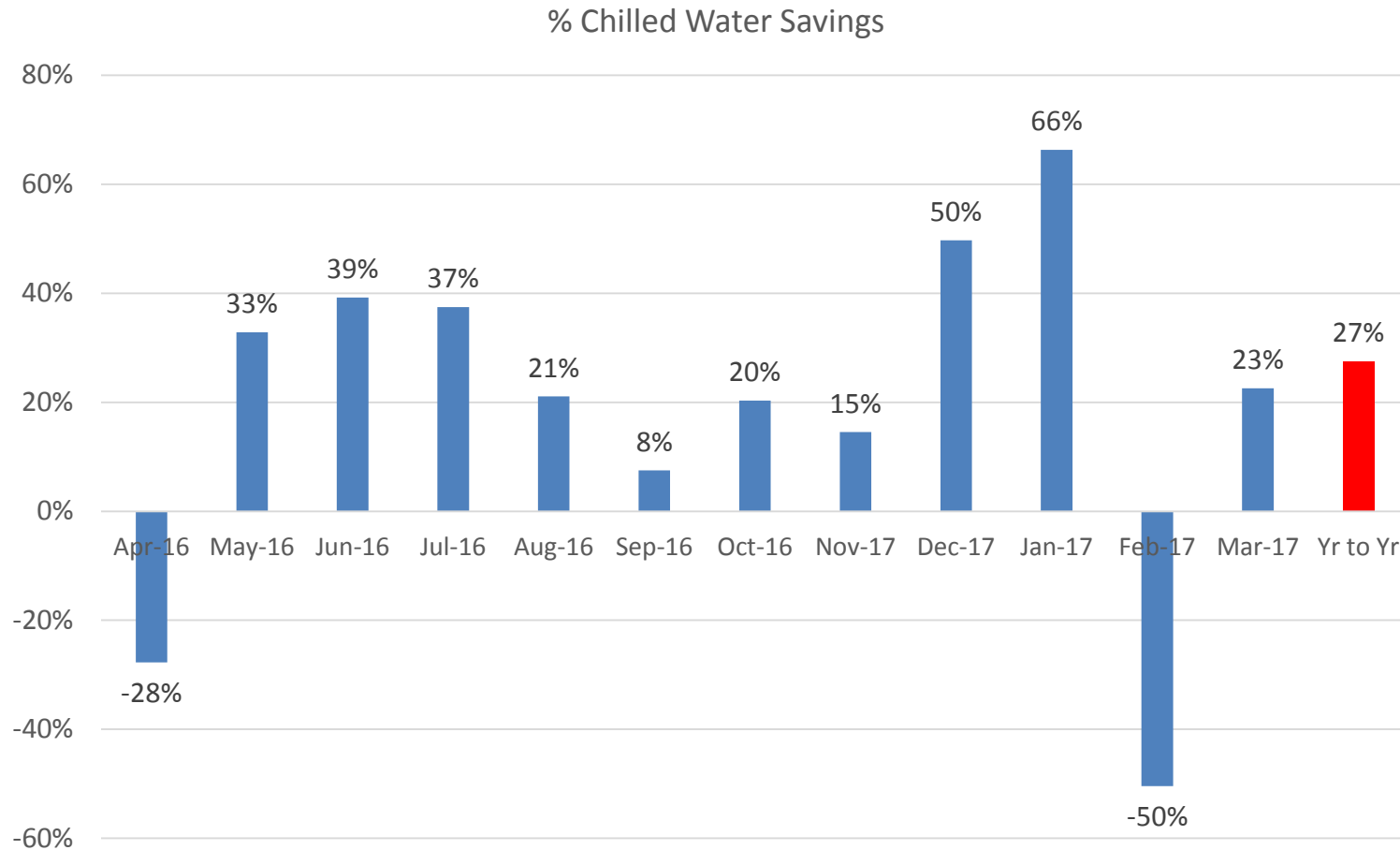
Project Results

Steam Use – % Savings



Project Results

Chilled Water – % Savings



Project Results

Energy Savings Summary – Total Building

<i>UTILITY</i>	<i>Yearly Reduction Ending March 2017 versus March 2016</i>
ELECTRIC	23.7%
STEAM	32.3%
CHILLED WATER	27.5%
TOTAL ENERGY	28.2%

Energy data not optimized for actual project implementation schedule (conservative).

Project Results

Cost Savings Summary – Total Building

<i>UTILITY</i>	<i>Yearly \$ Savings Ending March 2017 versus March 2016</i>
ELECTRIC	\$114,945
STEAM	\$135,420
CHILLED WATER	\$141,940
TOTAL SAVINGS	\$392,265

Energy component of utility bill only, does not include P&I and O&M fees

Summary

Project Costs

Total Project Costs - \$1,041,080, including

- Controls upgrade cost \$708,215 (353 terminal units, total of 211 controllers).
- TAB cost \$99,400 (TAB performed under controls contract).
- Cx Costs - \$39,600 – 4.9% of construction costs.

Summary

Project Returns

Actual Project Results	
Project Costs	\$1,041,080
Energy Savings	\$392,265
Simple Payback	2.7 years

Summary

Project Returns

	Actual Project Results	Performance Contract IGA
Project Costs	\$1,041,080	\$2,274,400
Energy Savings	\$392,265	\$424,773
Simple Payback	2.7 years	5.4 years

IGA costs include financing, active project management, additional measuring equipment (AFS), annual M&V, unknowns, etc.

Summary

Project Team

- UNC-CH - Engineering Services and Construction Management
- Dewberry Engineers – Design Engineering and Construction Administration
- Johnson Controls Inc – Controls and TAB contract.
- System WorCx – Commissioning Provider



Thank You

**Rod Rabold CxA Senior Cx
Engineer**

University of North Carolina – Chapel Hill

Rod.Rabold@fac.unc.edu

