CHAPTER/REGIONAL TECHNOLOGY AWARD - SHORT FORM

1. Category - Check one and indicate New, Existing, or Existing Building Commissioning (EBCx)

☐ Commercial Buildings	☐ New	☐ Existing or	☐ EBCx
Institutional Buildings:			
■ Educational Facilities	☐ New	■ Existing or	☐ EBCx
☐ Other Institutional	☐ New	☐ Existing or	☐ EBCx
☐ Health Care Facilities	☐ New	☐ Existing or	☐ EBCx
☐ Industrial Facilities or Processes	☐ New	☐ Existing or	☐ EBCx
☐ Public Assembly	☐ New	☐ Existing or	☐ EBCx
☐ Residential (Single and Multi-Family)			

2. Name of building or project: University of Chicago Medicine KCBD Retro-commissioning

City/State: Chicago, IL

3. Project Description: Retro-commissioning of Knapp Center for Biomedical Discovery

Project Study/Design Period: 01/2014 (Begin date (mm/yyyy)) to 07/2015 (End date (mm/yyyy))

Percent Occupancy at time of submission: 100%

4. Entrant (ASHRAE member with significant role in project):

a. Name: Matsen, Kurt and Shinnick, Tim
Last First Middle

Membership Number: 8140356 (Matsen) and 8151595 (Shinnick)

Chapter: Illinois

Region: VI

b. Address (including country): Grumman/Butkus Associates, 820 Davis Street, Suite 300

Evanston | IL | 60630 | USA
City | State | Zip | Country

c. Telephone: (O) 847-328-3555 d. Email: kmatsen@grummanbutkus.com

e. Member's Role in Project: Project Manager

f. Member's Signature: Kurt Matsen

Digitally signed by Kurt Matsen
DN: cn=Kurt Matsen, o=Grumman/Butkus Associates, ou, email=kmatsen@grummanbutkus.com, c=US
Date: 2016.09.30 15:19:35 -05'00'

5. Engineer of Record: Kurt Matsen

By affixing my signature above, I certify that the information contained in this application is accurate to the best of my knowledge. In addition, I certify that I have discussed this entry with the owner and have received permission from the owner to submit this project to the ASHRAE Technology Awards Competition.

UNIVERSITY OF CHICAGO MEDICINE (UCM) — KNAPP CENTER FOR BIOMEDICAL DISCOVERY RETRO-COMMISSIONING

Building Description

The Knapp Center for Biomedical Discovery (KCBD), completed in 2009, is an award-winning research building built to enhance and nurture a collaborative culture among the many medical programs housed within. The 330,000-square-foot building provides laboratories, a vivarium, and office space for various research groups including the Institute for Pediatric Molecular Sciences, devoted to the genetic influence of childhood diseases.

Primary heating for the medical campus is supplied by the University of Chicago's central high-pressure steam plant. Pressure-reducing valve stations and heating hot water converters are located in the lower level mechanical room. Low-, medium-, and high-pressure systems are used for clean steam generation, sterilizer equipment, and humidification. Heating hot water is used for AHU heating coils, terminal unit reheat coils, baseboard hot water heat, radiant heating panels, and fan coil units.

The ***chilled water system*** is variable secondary, constant primary configuration served by three water-cooled, electric centrifugal chillers. The total cooling capacity is 3,600 tons. Cooling is provided year-round.

KCBD's ***ventilation system*** includes a total of 18 AHUs. The breakdown of unit types includes four 100% OA VAV units for the vivarium, eight 80% OA VAV units with lab exhaust heat recovery, and six CV units serving mechanical spaces. The entire building is controlled by a DDC system.

Project Summary

KCBD was retro-commissioned by Grumman/Butkus Associates in two phases between 2014 and 2015 as part of the ComEd Smart Ideas Incentive Program. The intent of the first phase was to identify and implement low-cost, short-payback energy conservation measures to improve sustainability and reduce annual operating costs. The second phase was to focus on larger capital projects. Even though the intent of the retro-commissioning (RCx) project was energy efficiency, a couple of ongoing operational problems were revealed during early planning.

Due to apparent heating issues, it looked as if the building didn't have sufficient heating capacity. AHUs would often shut down in response to low-temperature safety switches; humidifiers would behave erratically in response to pressure changes; and the steam PRVs required constant maintenance. These problems led to extreme negative pressures in the building, resulting in elevators shutting down and lobby curtain walls frosting. Even though the KCBD was one of the newest buildings on campus, it had been a nightmare for the facilities staff and operating engineers. They were hesitant to allow the RCx team to propose changes to the critical AHUs or lab exhaust systems.

To model the building steam load, the engineers installed an ultrasonic flow meter on the various hot water systems and used trending data from the steam systems. The model suggested that the building had a design capacity of approximately 177% of the estimated peak building steam load. Design capacity was ample, but there was clearly some problem with how that capacity was being used.

RCx investigation identified multiple issues that were limiting the capacity of the building heating systems. These issues involved the steam system and air handling units. The engineer determined that a holistic approach would be necessary, and that correcting each of these issues individually would not resolve the operational issues.

Each of the eight laboratory air handling units contains a heat recovery coil, return damper (RAD), preheat coil and cooling coil, while return fans are shared between four paired sets of the AHUs. Three issues were identified regarding the AHU temperature control/unit configuration.

First, the design sequence noted that the when the heat recovery water leaving temperature dropped below 30°F, the three-way control valve was supposed to modulate closed. Instead of modulating the heat recovery valve to maintain a leaving temperature of 30°F, the valve would actually close quickly. This resulted in a quick drop in MAT and main heat recovery supply water temperature. Consequently the AHU would trip off on low-temperature, and the other AHUs would trip due to the drop in temperature of the heat recovery fluid temperature.

Second, each air handling unit would control its own RAD to maintain the DAT setpoint while the preheat coil would operate to maintain the preheat coil discharge temperature (PHT) setpoint. This caused fighting between the two systems: as the preheat valve would modulate open to maintain the PHT, the DAT would be affected, causing the return damper to close. This scenario was preventing heat recovery of the return air and resulting in low-temp trips. Additionally, if an AHU preheat valve were to modulate closed, causing a small drop in DAT, the return damper would open. Unfortunately, the AHU return dampers were not pressure-independent, so when one AHU return damper would open, return air would be stolen from the paired AHU. This would again cause a drop in MAT and a low-temp trip condition of the other unit.

Third, because of the previous issues, the controls sequence had been modified to enable the preheat valves when OAT reached 39°F and to start the valves 100% open. The AHUs would quickly overshoot the PHT setpoint (and DAT again) and the preheat valve would close. Because the valve was closing but the heating load was increasing as the OAT decreased, the AHU could trip off on low-temperature limit. Also, since all AHUs would enable their preheat valves at the same time, there was a drastic increase in the low-pressure steam demand. The steam PRVs would open up significantly to satisfy the load. The preheat heat exchangers would take most of the steam, and the AHU steam humidifiers would start to open their valves more to maintain the same humidification. The preheat system load would satisfy quickly because the AHU valves would start closing, and the heat exchanger steam valves would start closing as well. The humidifier valves were then open more than necessary, so the AHUs would start humidifying excessively.

Two more issues were identified with the steam system that limited the capacity of the heating system. First, the preheat hot water heat exchangers were served by 1/3 and 2/3 steam valves. The two 1/3 valve pneumatic actuators were failed, forcing the valves closed. The BAS was still commanding the 1/3 valves open, but operators did not know they were closed since the 2/3 valves operated correctly. This caused a drop in system capacity.

Second, the low pressure steam PRV station was not set up correctly. The station had three parallel lines, each with a primary and secondary PRV. All of the secondary PRVs were set to maintain the low-pressure setpoint of 15 psi. The secondary PRVs would often fight each other since they were trying to maintain the same setpoint. This fighting caused large swings at the upstream pressure gauge, contributing to the theory that the campus system was to blame. Through RCx, the PRVs were adjusted to setpoints of 15 psi, 13 psi, and 11 psi allowing them to stage properly.

Energy Efficiency: All of these issues combined led to instability with the heating and steam systems. By correcting each of these issues, the heating system was able to use return air and the energy recovery system to improve energy efficiency. Annual savings of 88,000 therms were verified.

Operation and Maintenance: O&M was drastically improved by steadying temperature and pressure control, reducing the amount of AHU shut downs from low-temperature safety switches and reducing wear on the steam PRVs.

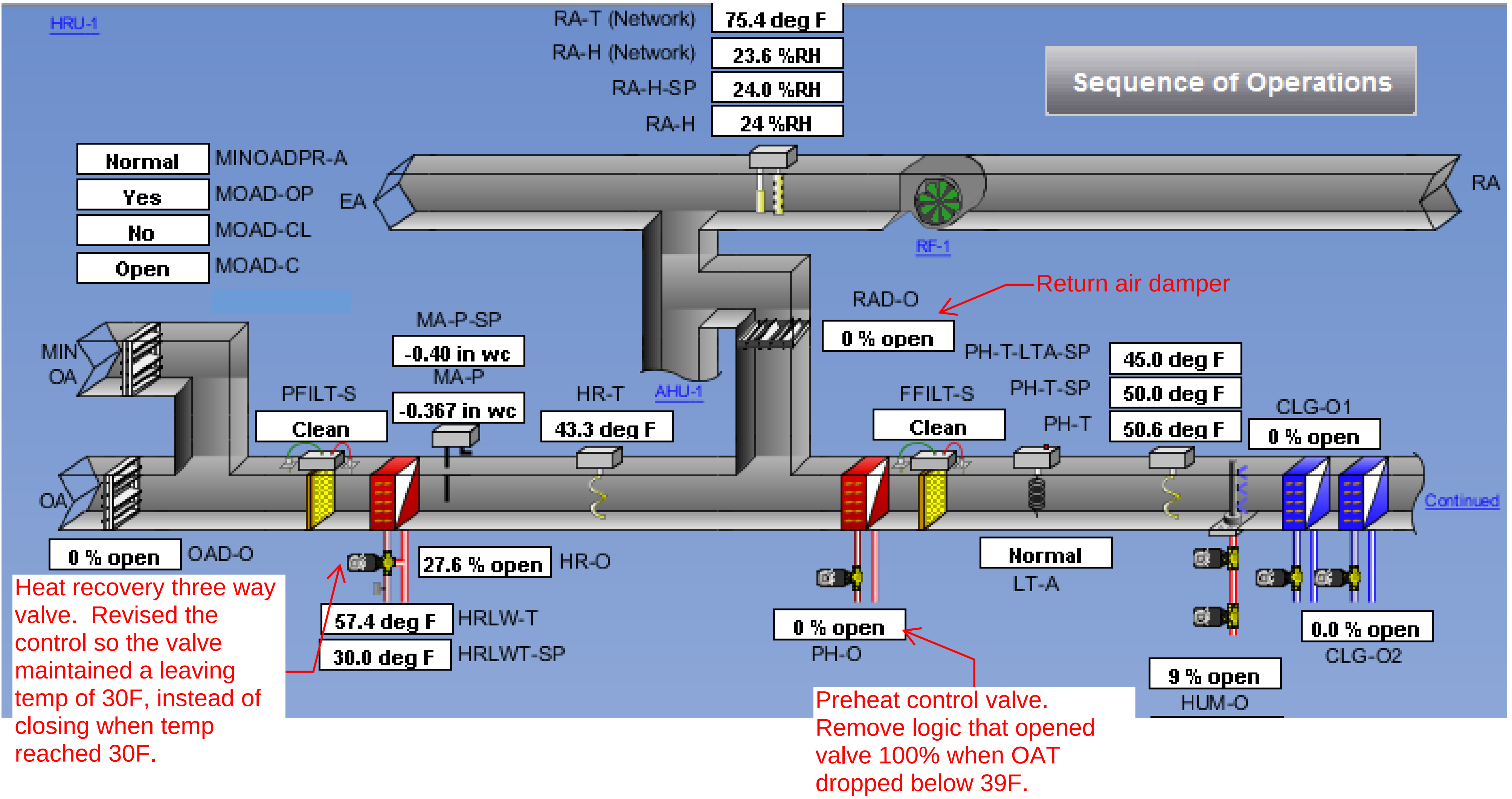
Indoor Air Quality: Corrections as indicated led to a significant improvement in the stability of the HVAC systems and proper filtration and control of ventilation air.

Innovation: Initially, it appears that some innovation and an extreme design change would be necessary to fix the building. However, through several detailed site investigations and data analysis, the RCx team was able to make the building work with the existing equipment despite initial doubts.

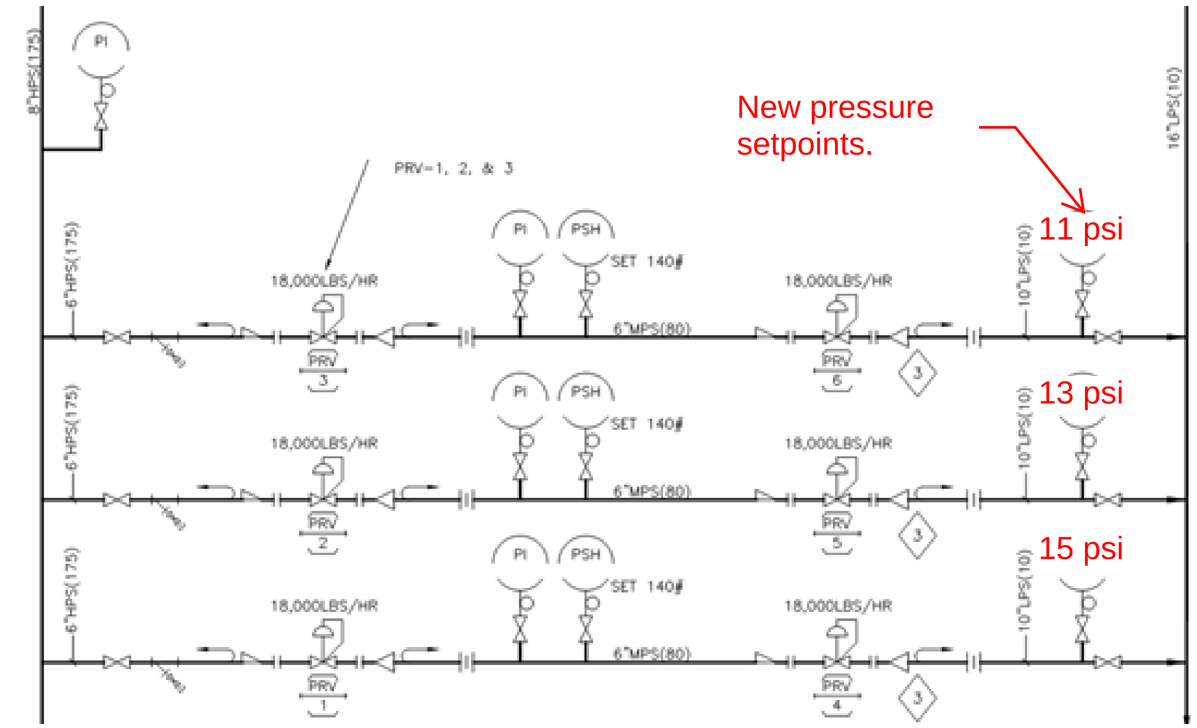
Cost Effectiveness: Phase I was funded by the ComEd Smart Ideas Program and resulted in verified savings of $106,000 per year with a payback of less than a year. Phase II found additional low-cost controls modifications and equipment repairs that could improve the building operation instead of major design modifications.

Typical AHU Controls System Screenshot

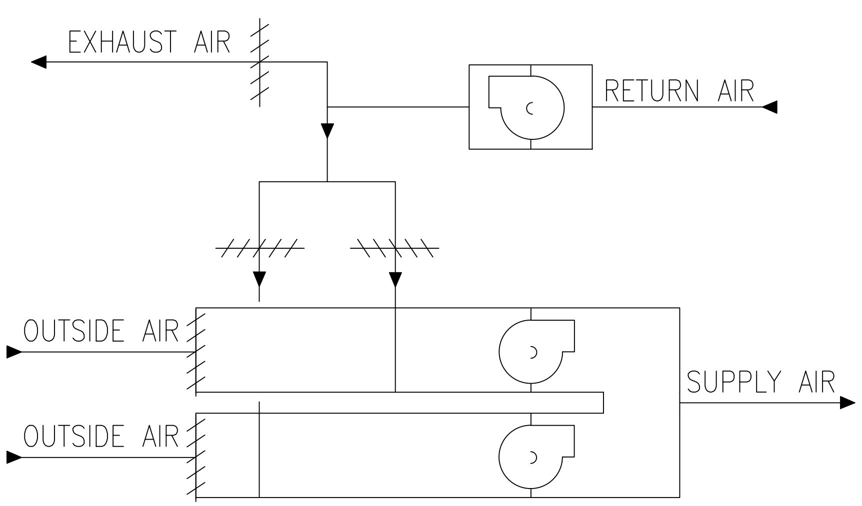
In addition to the modifications described below, the control of the heat recovery valve, return air damper and preheat control valve were integrated together to allow for consistent operation.



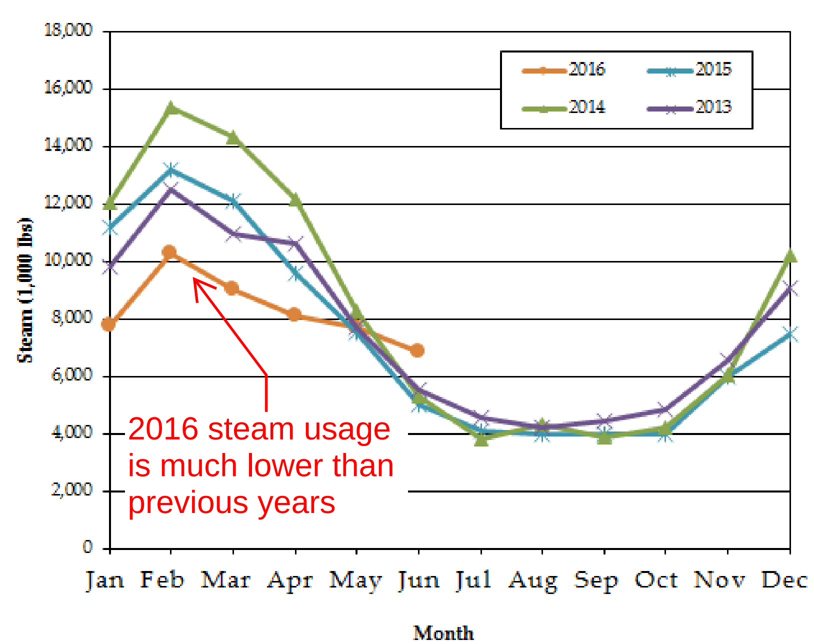
Low Pressure Steam PRV Station



Parallel AHU Configuration



Monthly Steam Usage



Building Steam Model