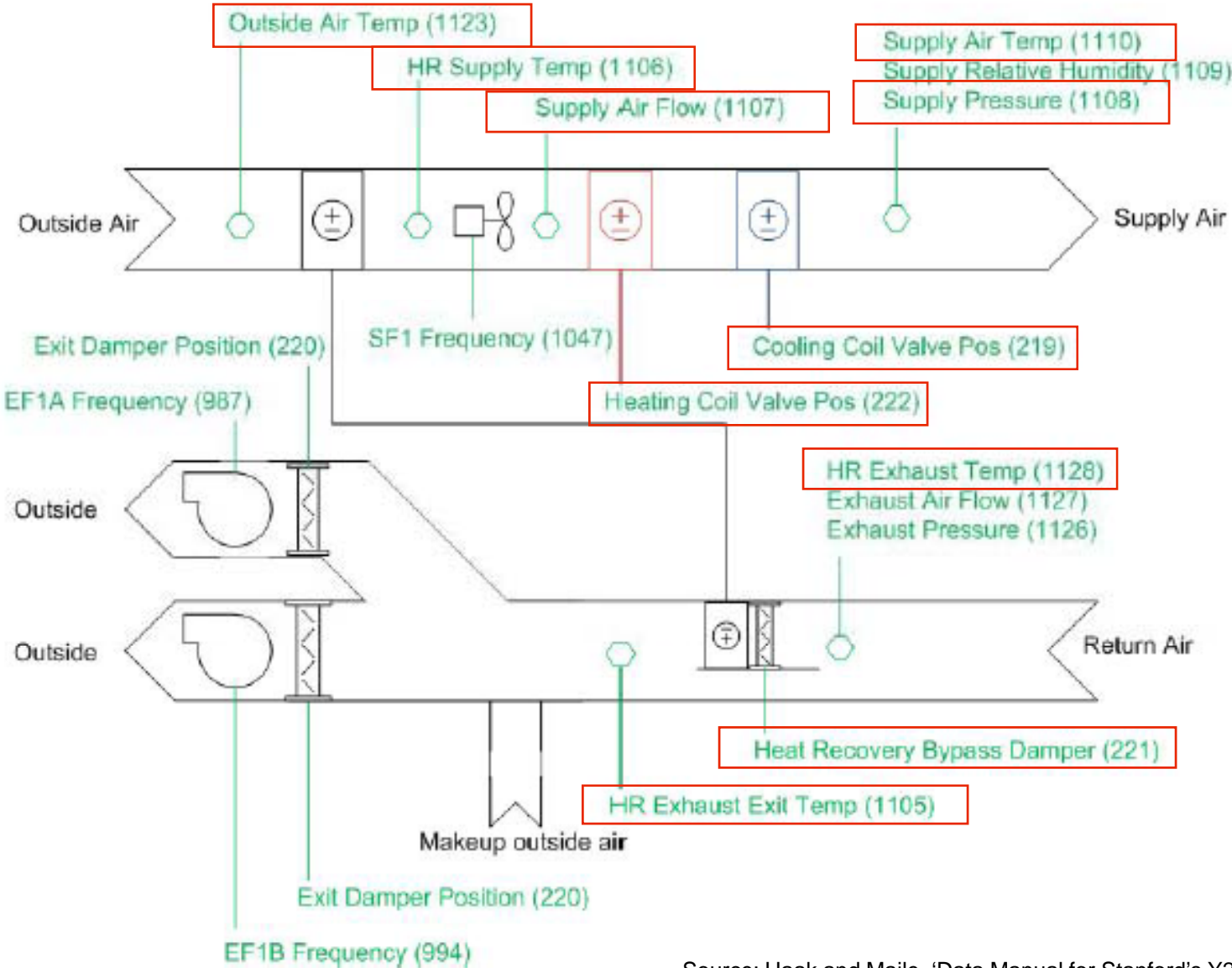


AHU 1

Chris Trigg

June 3, 2009

System Overview

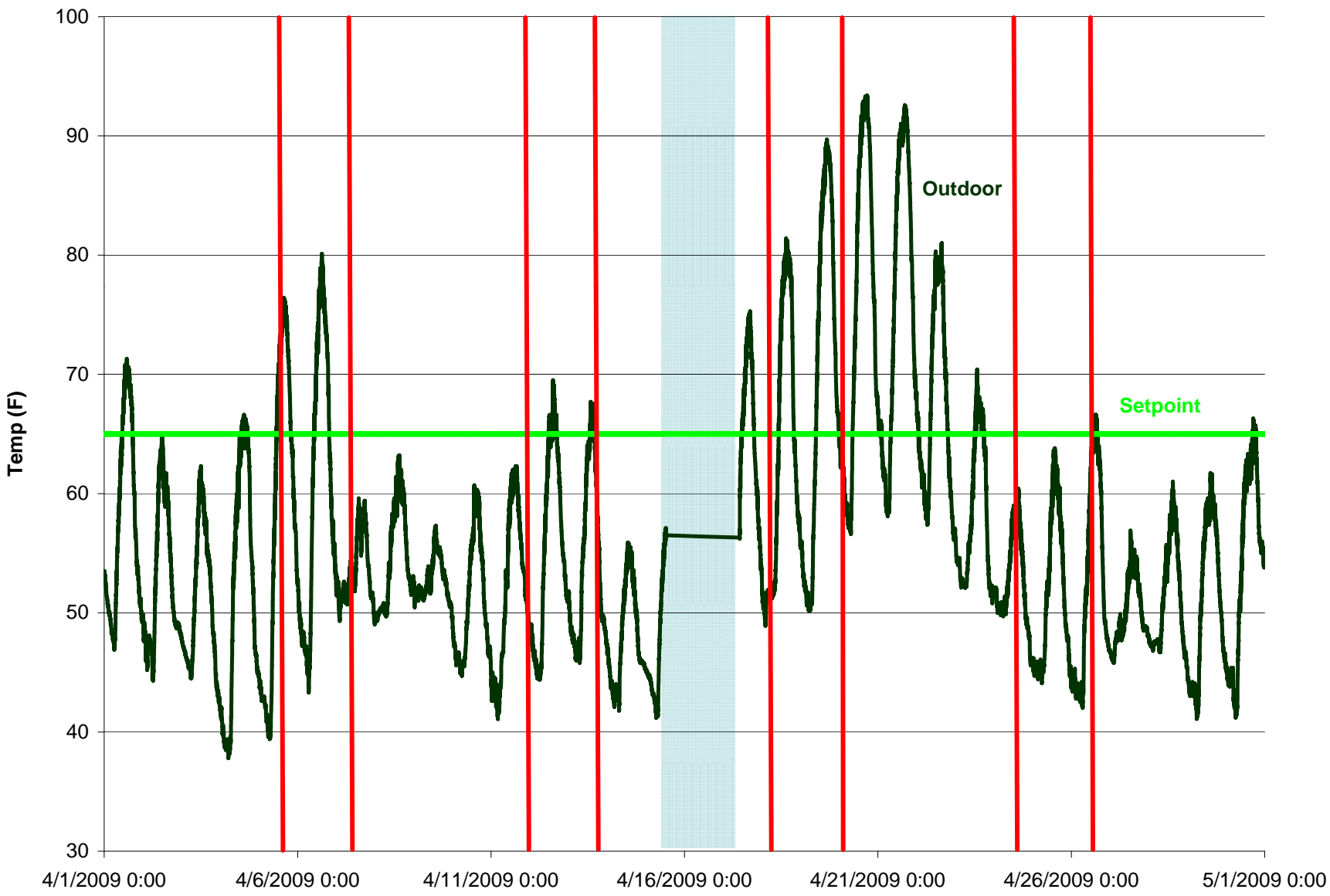


Source: Haak and Maile, 'Data Manual for Stanford's Y2E2 Building', 2009

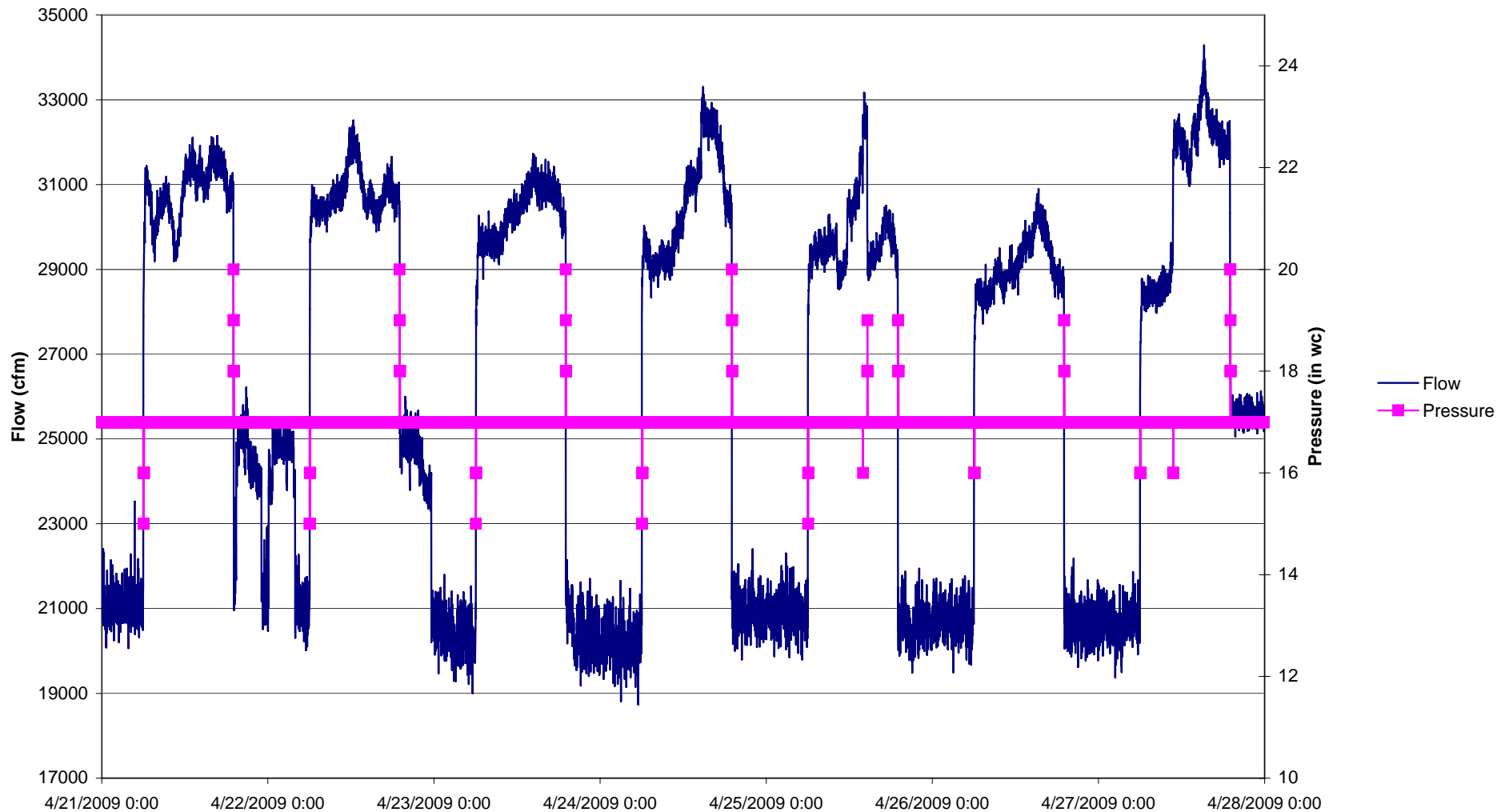
Data Summary: AHU1 was studied for the month of April with particular attention paid to temperature sensors, valve positions as well as pressure and flow interactions.

Number	219	221	222	1107	1108
Name	Cool Coil Valve Position	Bypass Valve Position	Heating Coil Valve Position	Supply Flow	Supply Pressure
Unit	%	%	%	cfm	in wc
Location	AHU 1	AHU 1	AHU 1	AHU 1	AHU 1
Count	39272	39268	39284	39278	39276
Min	0	0	0	18739	15
Max	68	100	26	34651	21
Avg	7.70	83.50	3.27	26023.66	17.00
Std	17.95	37.12	6.37	4609.63	0.15
CoV	2.33	0.44	1.95	0.18	0.01
First	4/1/2009 0:00	4/1/2009 0:00	4/1/2009 0:00	4/1/2009 0:00	4/1/2009 0:00
Last	4/30/2009 23:59	4/30/2009 23:59	4/30/2009 23:59	4/30/2009 23:59	4/30/2009 23:59
Classification	Sys Response	Sys Response	Sys Response	Func. Setpoint	Func. Setpoint
Number	1110	1123	1128	1105	1106
Name	Supply Temp	Outdoor Temp	Exhaust (Building) Temp	HR Exit Exhaust Temp	HR Supply Temp
Unit	°F	°F	°F	°F	°F
Location	AHU 1	Outdoors	Interior	HR Unit	HR Unit
Count	39275	39281	39284	39284	39279
Min	53.1	37.8	69	49.5	50.9
Max	70.6	93.4	74.7	84.5	83.8
Avg	65.96	56.42	70.94	62.04	62.60
Std	1.77	10.93	1.14	6.94	5.84
CoV	0.03	0.19	0.02	0.11	0.09
First	4/1/2009 0:00	4/1/2009 0:00	4/1/2009 0:00	4/1/2009 0:00	4/1/2009 0:00
Last	4/30/2009 23:59	4/30/2009 23:59	4/30/2009 23:59	4/30/2009 23:59	4/30/2009 23:59
Classification	Func. Setpoint	Exogeneous	Outcome Behv.	Outcome Behv.	Func. Setpoint

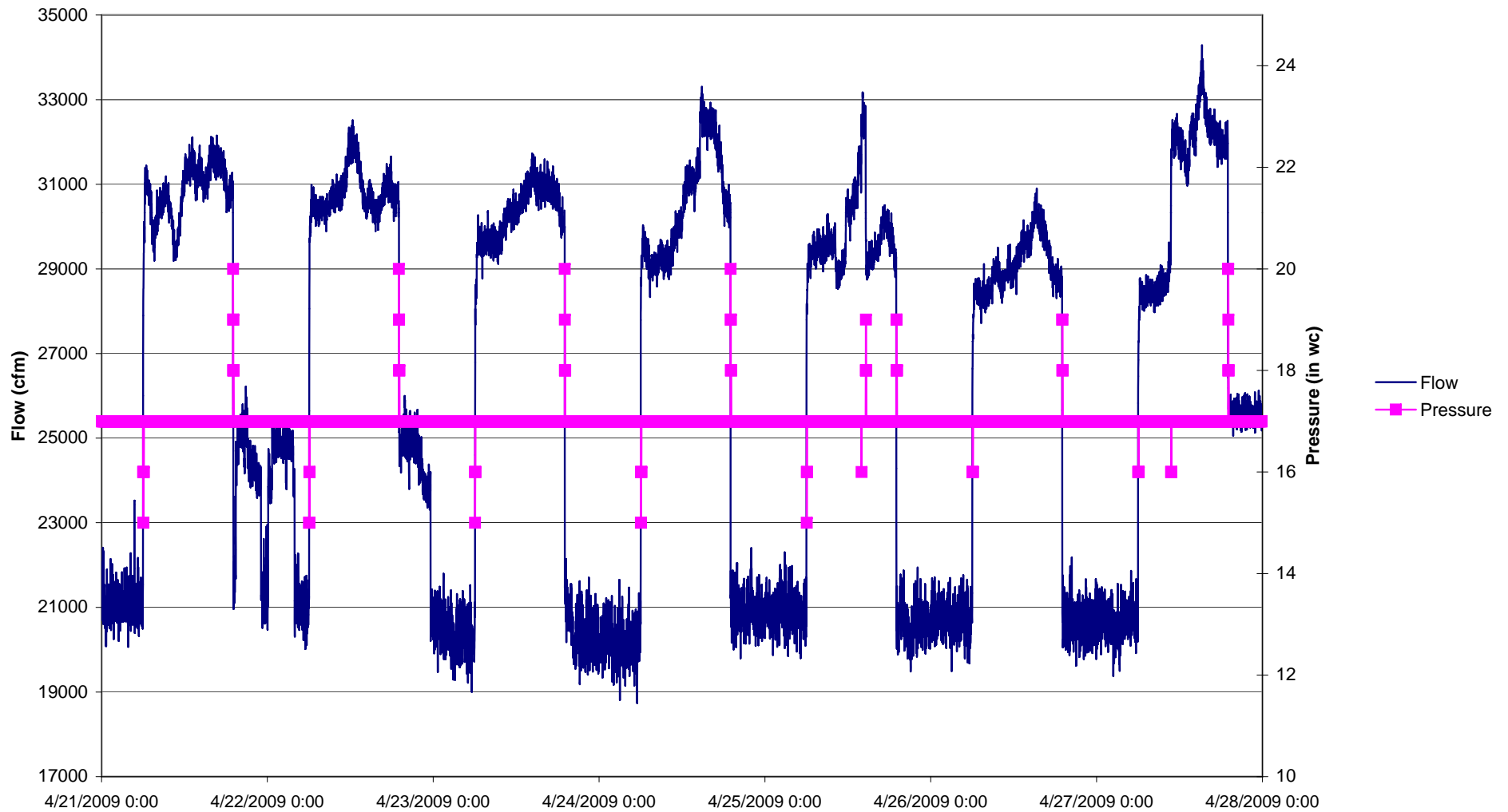
Functional Requirements- Temperature setpoint (65F) is the same over the entire month. Daily temps were approximately +/-25F of setpoint.



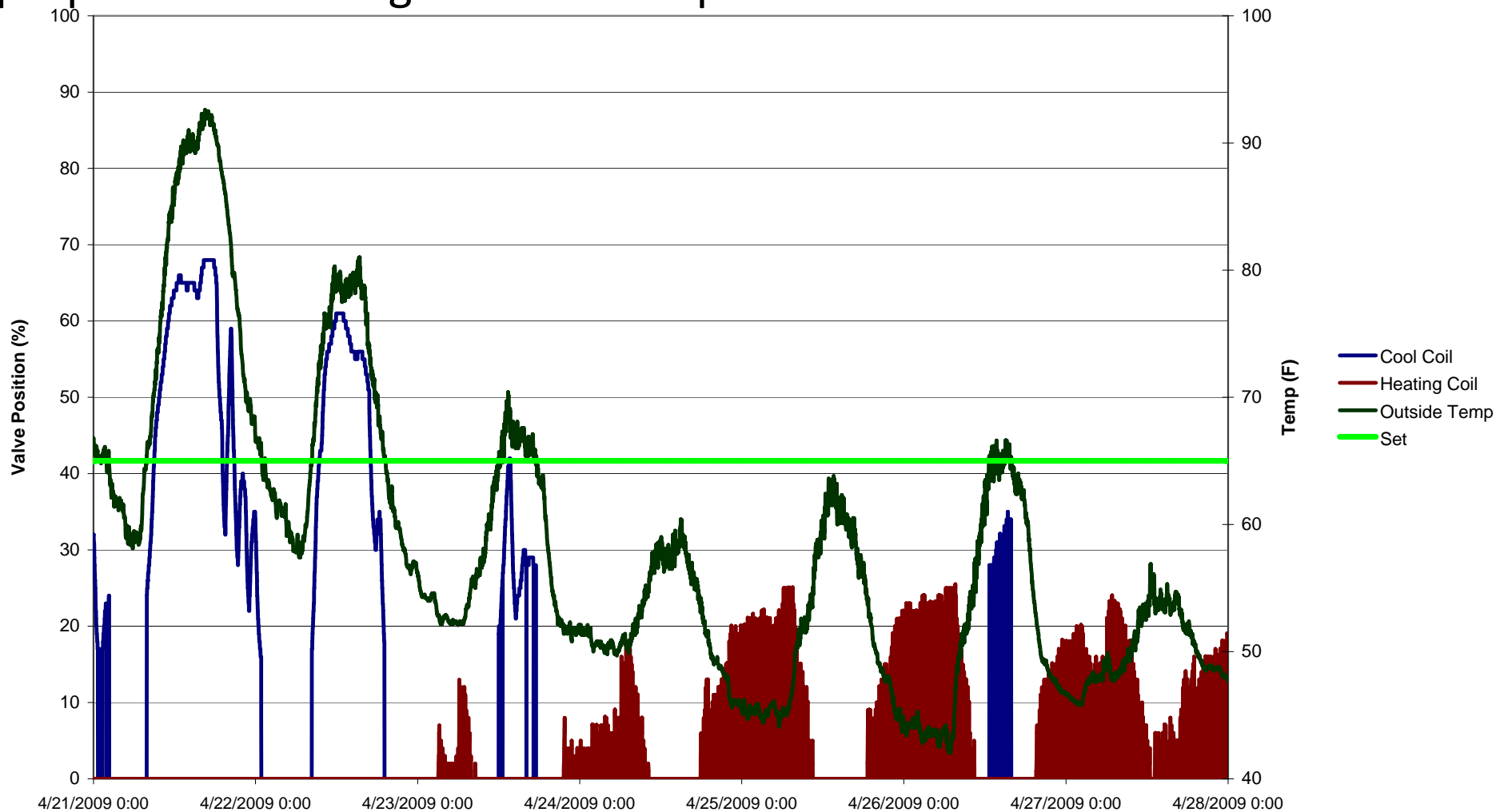
Functional Requirement - Supply pressure, while not given, has assumed setpoint of 17 in wc. Flow varies between occupied ($\approx 30,000$ cfm) and unoccupied ($\approx 20,000$ cfm).



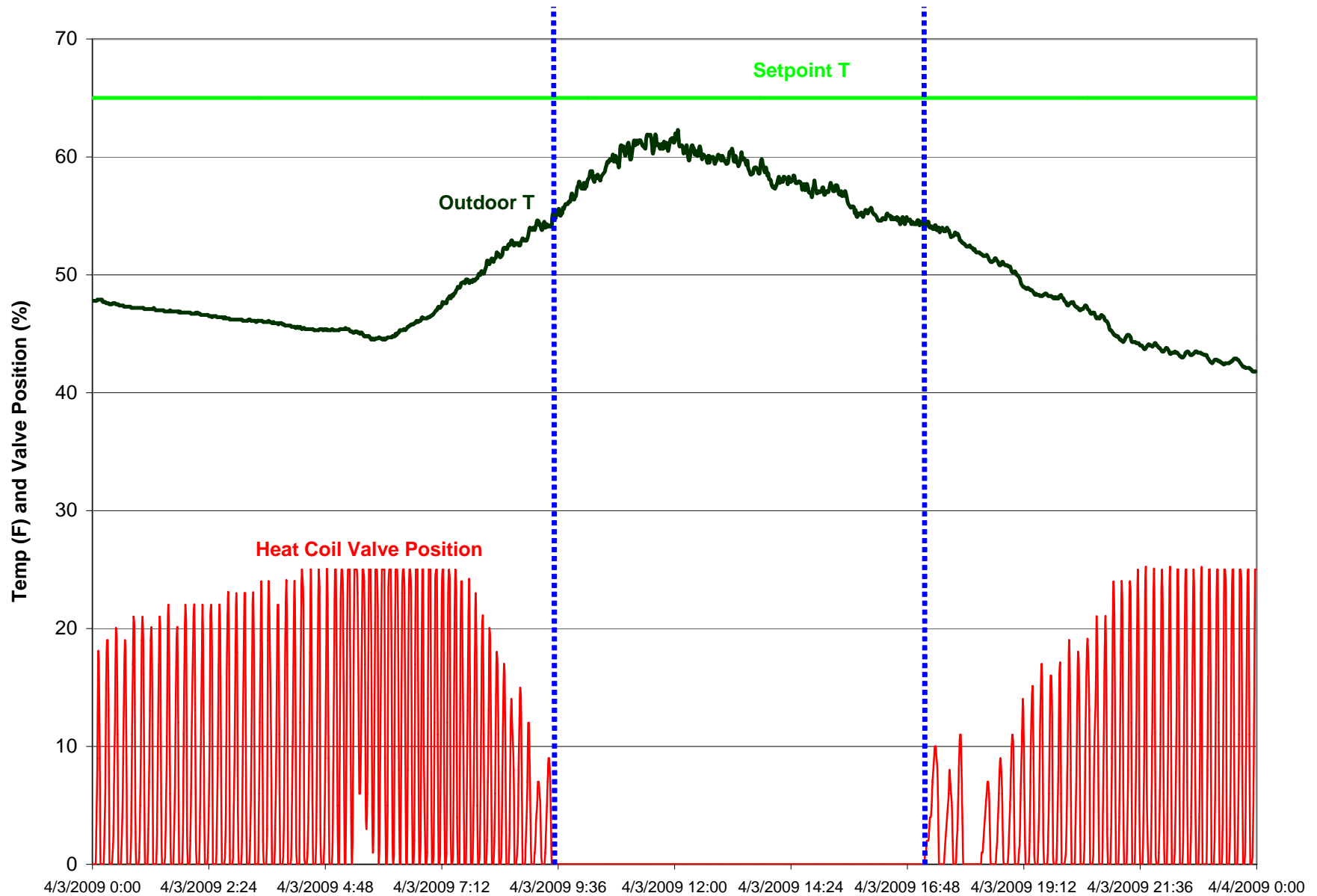
System Response- Pressure deviates from assumed setpoint for 3-7 minutes in response to changes in flow from occupied to unoccupied mode.



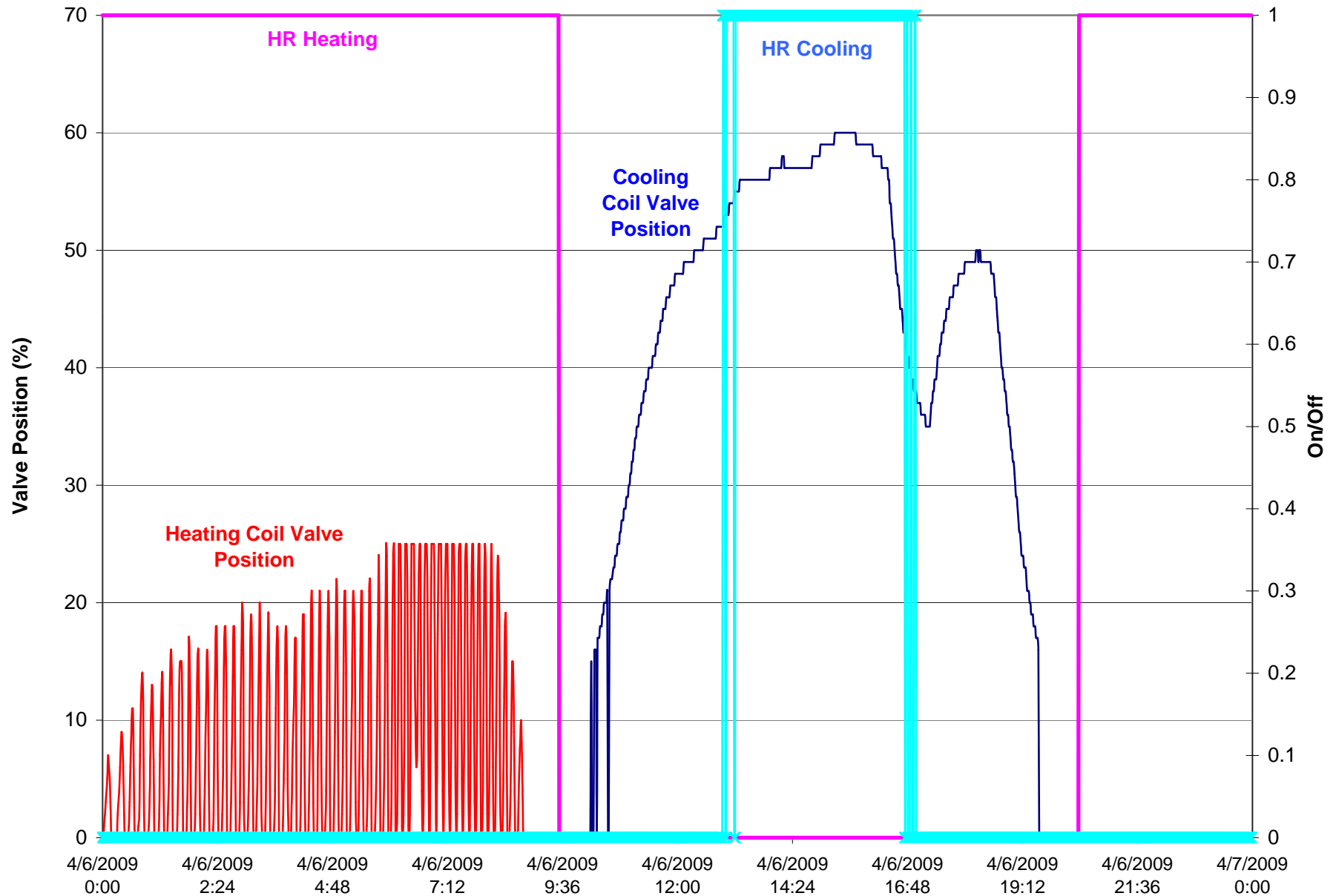
System Response- Cooling coil valves open when outdoor temp > 65 degrees (setpoint and heating coil valves when outdoor < 55 degrees . The valves are never simultaneously open, and valve position is proportional to magnitude of temperature difference.



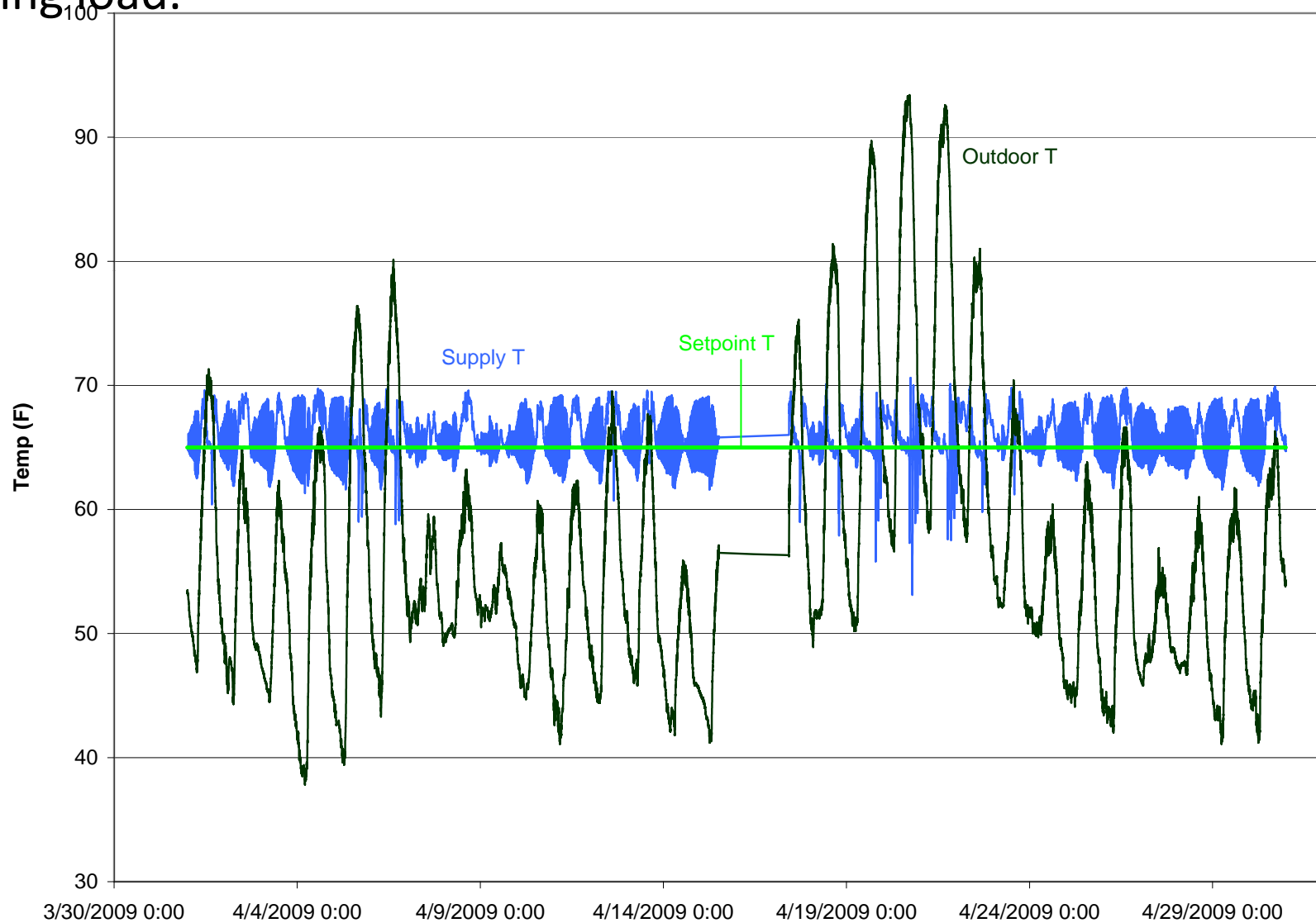
System Response- Heating coil valves are only at appropriate times, however they fluctuate open/closed rapidly in small time increments.



System Response- HR unit operates in coordination with heating and cooling coils.



System Performance- Supply temp varies +/- 5F from setpoint. Days with outdoor temps significantly higher than setpoint show larger daily range of supply temp (often with temps > 5F below setpoint) from large cooling load.



Recommendations – (In reference to previous plots)

Proper Response

Air supply flow and pressure show proper correlation and operate at or near the assumed setpoints.

Cool coil valve is operating properly both in terms of when it is open and closed and the magnitude of its position.

HR Unit operates in coordination with the heating and cooling coils.

Improper Response

Heating coil valves, while operating correctly in response to the outdoor air temp, fluctuate on and off over small timescales when a sustained opening would be expected. Facilities should check and repair any problems for smoother operation of the valve.

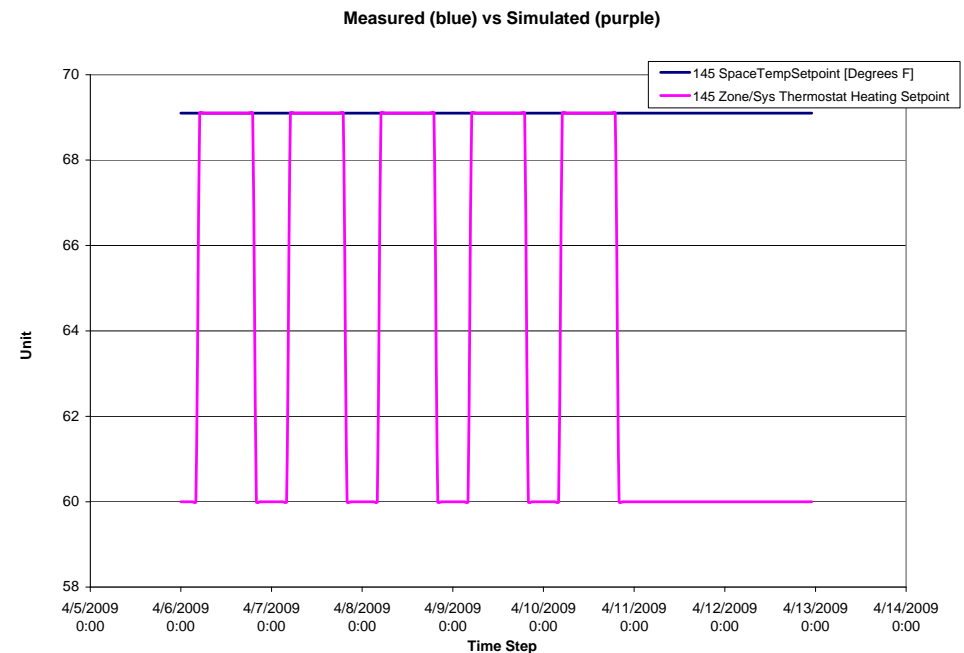
Measured and Simulated Data Comparison

Common Issues

Setpoints in all offices fluctuate throughout the day in the simulations but are measured as constant. Potential occupant behavior issue.

Supply temperature to the active chilled beam hot/cold water loops and radiative heater hot water loops significantly different (up to 5-40 degrees) between simulations and measured data.

Generally similar trends in space temperatures, although typically off by 3-5 degrees.



BIM Guide

Model

Exterior Walls (Revit and E+)

Wall-linked Windows and Doors (Revit and E+)

Roof and Ceilings (Revit and E+)

Shading Devices (E+, some difficulty in interface transfer from Revit)

Tagged Spaces with Type (Revit and E+)

2nd Level Space Boundaries (E+)

HVAC Equipment/Configuration (E+)

BIM Model

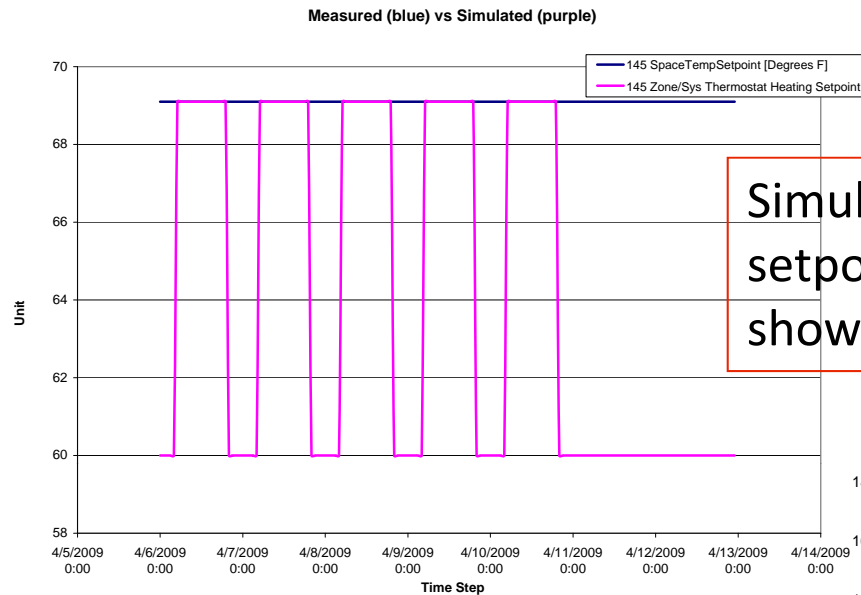
Rules

1. Utilize the data's granularity. Trends over a period of minutes often point to problems while encompassing longer trends can be misleading.
2. Evaluate individual sensors with respect to other related sensors.
3. Flow/Pressure: Supply flow should vary between occupied ($\approx 30,000$ cfm) and unoccupied ($\approx 20,000$ cfm) flow rates each day. Supply pressure should maintain 17 in wc. with short term variations expected from changes in supply flow.
4. Cooling coil valves should open when outdoor temperatures rise above 65F and should open proportional outdoor temp. Heating coil valves should open when outdoor temperatures fall to approximately 55F and should open proportional outdoor temp.
5. The heat recovery unit should operate in coordination with the heating and cooling coils.

Thank You
Questions

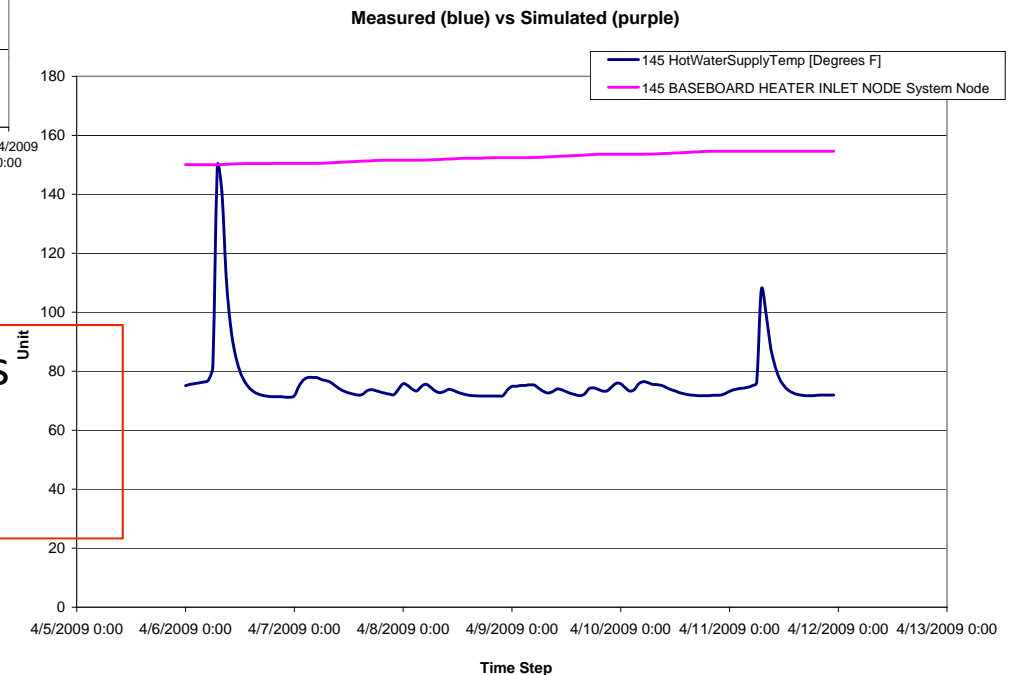
Appendix- Comparison of Modeled and Predicted Data Full Analysis

Room 145 (Typical)



Simulation shows variation in temp setpoint based on time of day, but actual shows no change.

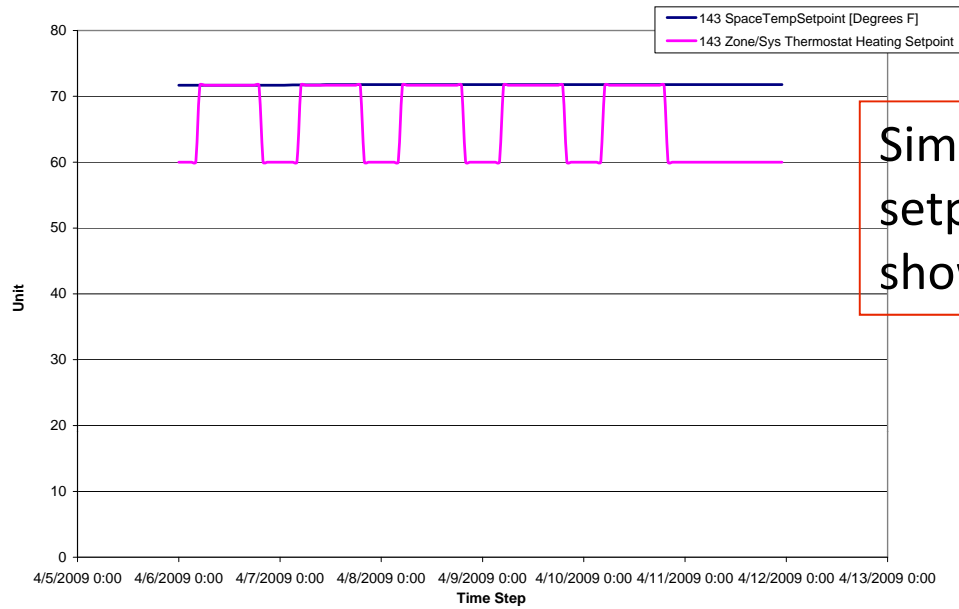
Measured supply temp to radiators is significantly lower than simulated (similar trend in return temp).



*Data for radiant heater valve position and hot water flow showed close correlation. No measured data was available for comparison to simulated plug loads.

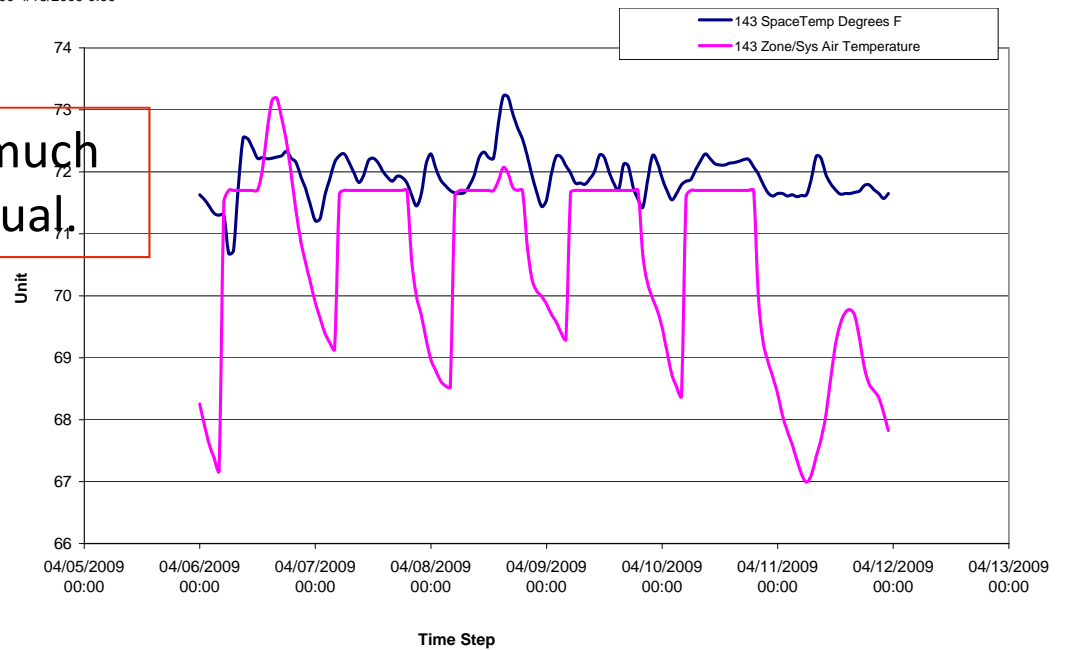
Room 143 (Typical)

Measured (blue) vs Simulated (purple)



Simulation shows variation in temp setpoint based on time of day, but actual shows no change.

Measured (blue) vs Simulated (purple)



Simulated temperatures show much larger diurnal variation than actual.

Room 145 and 143

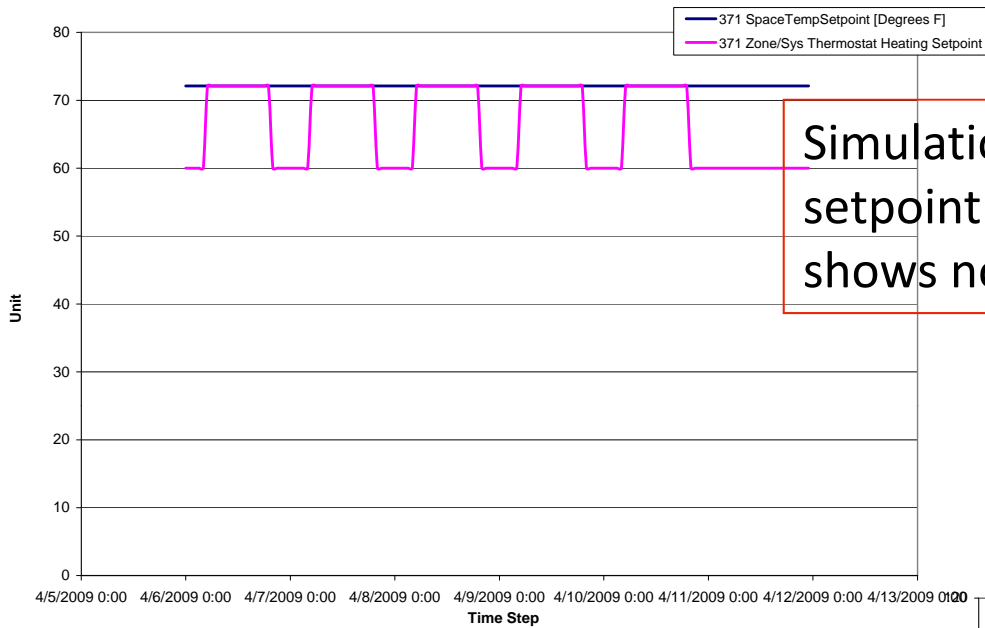
*In EnergyPlus, ceiling fans could not be modeled for the rooms. Additionally, radiant heater valve position could also not be simulated and so measured data was compared to simulated flow.

*While both rooms showed simulated space temperature varying more than actual space temp, the temperatures varied in phase in room 145 but in room 143 there was often no correlation between when the simulated temperature would fall/rise and when the actual temperature would

*The measured lack of variation in setpoint temp points to occupant behavioral issues. That is, occupants may be unaware of the intended functional abilities of the room temperature control. Also the discrepancy between measured and simulated hot water supply temp to the radiator in 145 may be an indication of the actual system behavior not matching its functional intent, or could be an important point for model calibration.

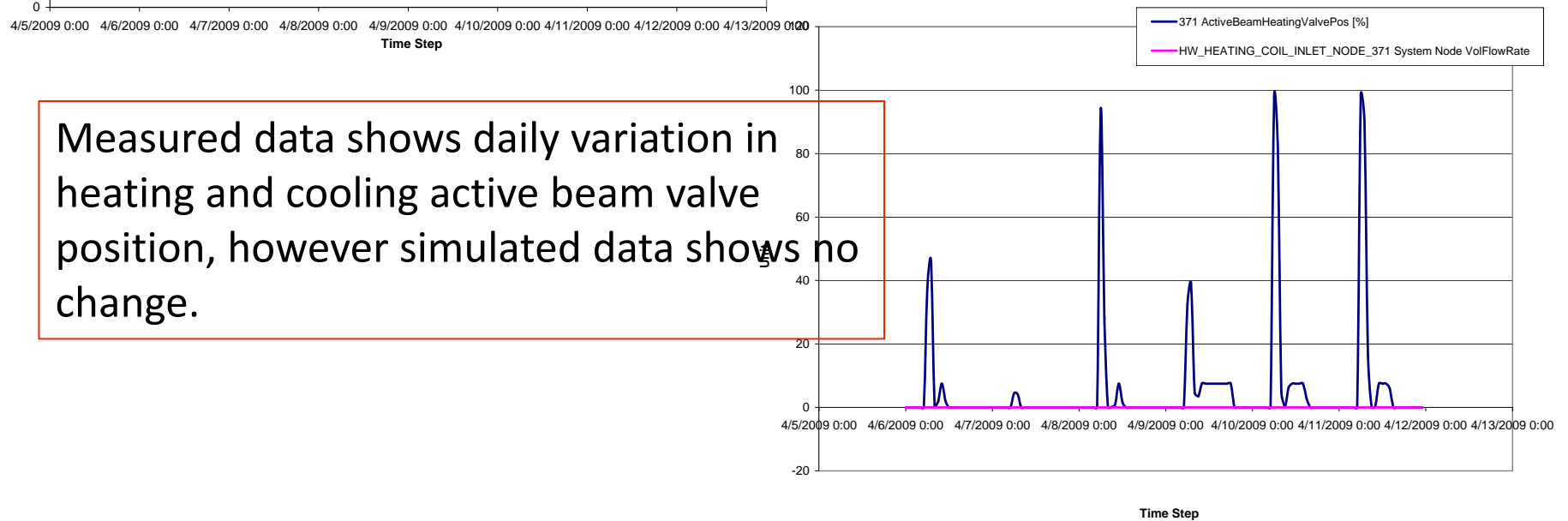
Room 371 (Representative)

Measured (blue) vs Simulated (purple)



Simulation shows variation in temp setpoint based on time of day, but actual shows no change.

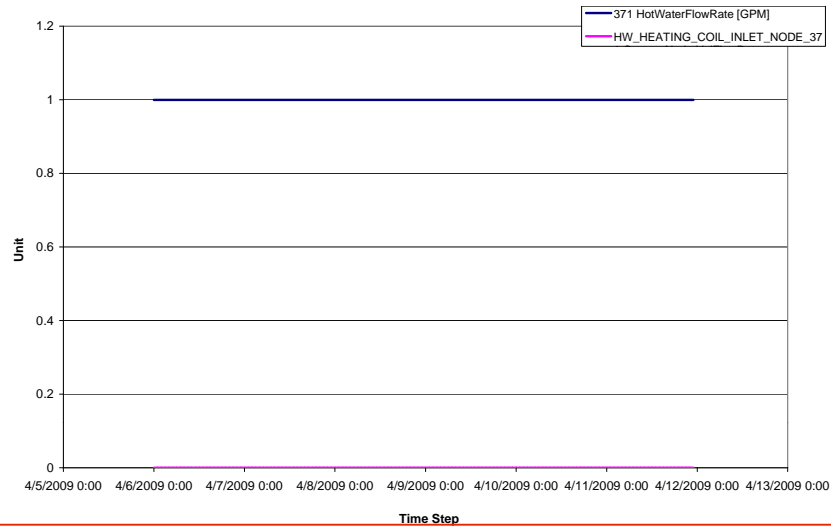
Measured (blue) vs Simulated (purple)



Measured data shows daily variation in heating and cooling active beam valve position, however simulated data shows no change.

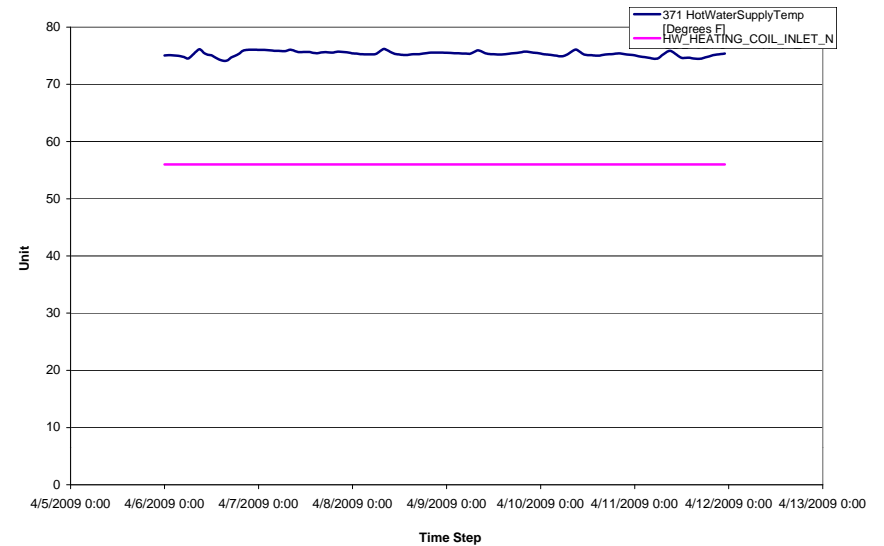
Room 371 (Representative)

Measured (blue) vs Simulated (purple)



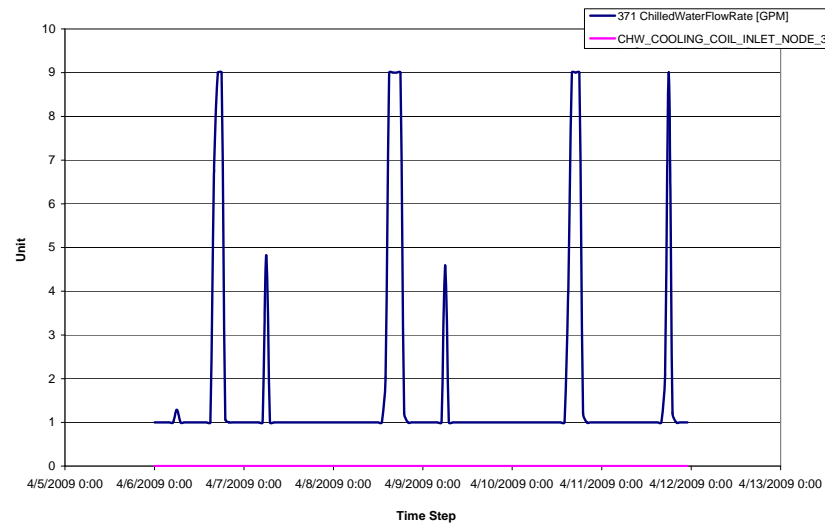
Simulation showed no hot or cold water flow to beam, but actual data shows constant flow hw and varying cw flow

Measured (blue) vs Simulated (purple)

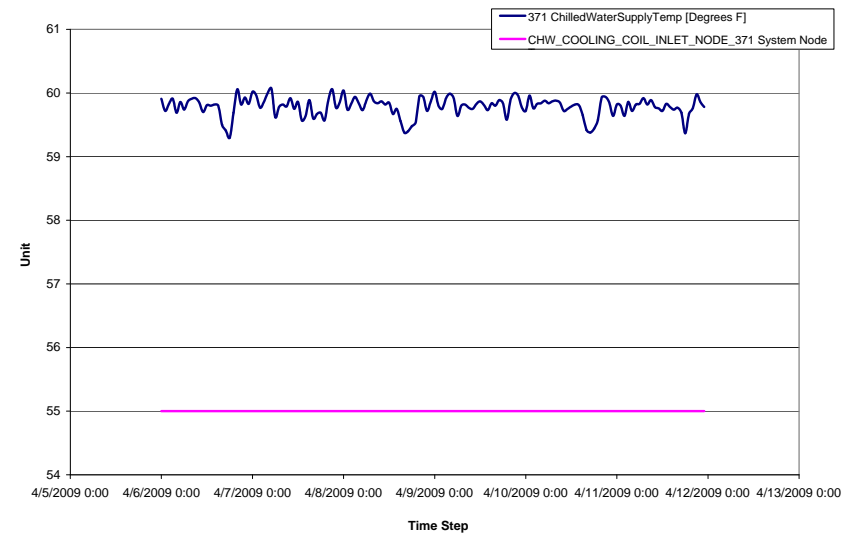


Measured hot/cold supply/return temps were always higher (5-40 degrees) than simulated.

Measured (blue) vs Simulated (purple)

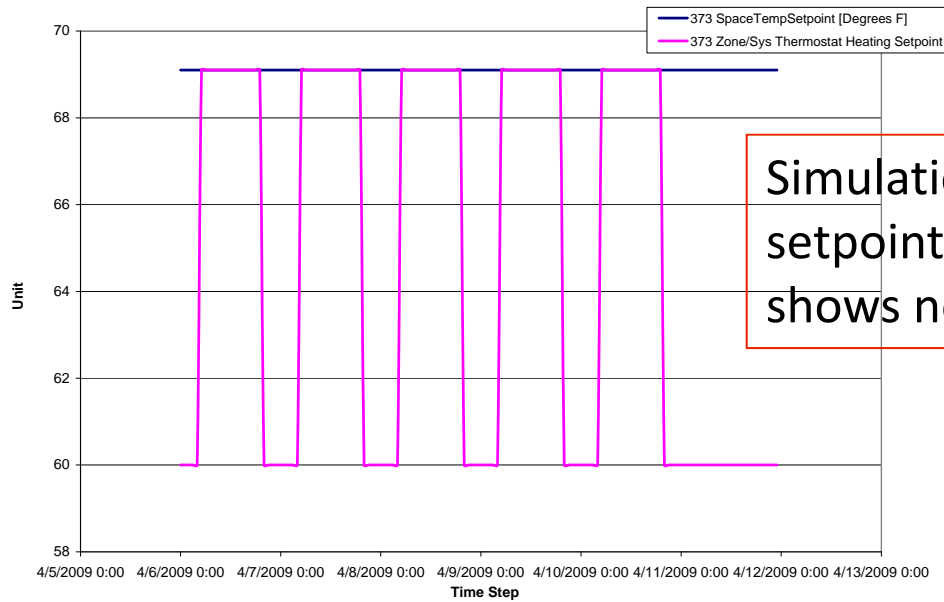


Measured (blue) vs Simulated (purple)



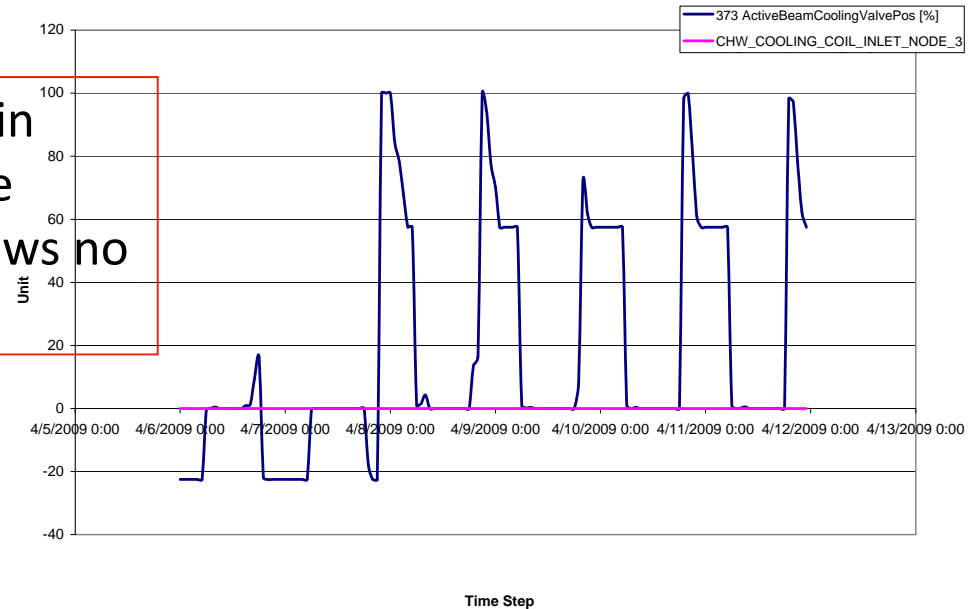
Room 373 (Typical)

Measured (blue) vs Simulated (purple)



Simulation shows variation in temp setpoint based on time of day, but actual shows no change.

Measured (blue) vs Simulated (purple)



Measured data shows daily variation in heating and cooling active beam valve position, however simulated data shows no change.

Room 371 and 373

It should be first noted that online documents refer to room 373 as the representative, but based on the amount of data in the spreadsheets 371 is representative. For the purposes of this presentation, the labels on the spreadsheets were used.

*For the active chilled beams, no valve positions (heating or cooling) can be simulated in EnergyPlus, therefore the actual data was compared to simulated flow.

*Both the representative and typical rooms showed similar behavior: space temps fluctuated in phase with simulated temperatures being slightly higher, the simulated space temp setpoints varied while the measured did not, and the measured coil valve positions fluctuated while the simulated did not.

*Again like 143 and 145, lack of setpoint variation could indicate an occupant behavior issue that if correct through education could improve system performance. Also, the discrepancies of both flow and temp settings may indicated that the beams are not behaving properly , although they could be from a difference in actual weather to modeled weather, or a need to calibrate the model.