Air Handling System Retro-Commissioning Trending Analysis

Critical Systems TESTING

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AIR HANDLING UNIT TRENDS

1. **The trending charts provided on the following pages prepared as part of a retro-Commissioning investigation. The operations shown were typical of six 35,000 cfm AHUs that served an office building located in the Midwest.**
2. **The charts were part of a retro-commissioning investigation that resulted in extensive sequencing modifications at a low cost and high savings.**
3. **Trending multiple processes and evaluating the interactive impacts allows for integrated approach toward retro-commissioning**
4. **The charts indicate non optimized economizer control, non operative demand control ventilation control of minimum outside air dampers , excessive pre-heat load due to non optimized mixed air control of mixed air dampers.**
5. **The charts indicate how each deficiency has a related impact on other control processed such as elevated ventilation rates during cold outside air temperatures due to inefficient control of outside air dampers resulting in increased return fan energy for building relief and excessive heating loads.**

Air Handling Unit Sequence of Operations

- Scheduled occupancy control that starts AHUs at 6:00 a.m. and shut off at 5:00 p.m.
- Supply fan VFD is controlled to maintain a fixed static pressure setpoint of 2.0 inches W.C.
- The supply fan monitors supply fan airflow CFM.
- Return fan VFD is controlled to maintain a CFM offset value from the supply fan airflow CFM. The return fan monitors return fan airflow CFM.
- Economizer control has points for both Dry Bulb and enthalpy based control.
  - The Dry Bulb Economizer is enabled based on a fixed outside air setpoint of 55ºF (adj.)
  - The Enthalpy Economizer is enabled based on a comparison between the return air and outside air enthalpy.
- Chilled water valve controls to maintain a fixed discharge air temperature setpoint of 58-60 deg. F (adj.).
- The chilled water valve is locked out at an outside air temperature setpoint of 50 deg. F.
- Two sets of outside air dampers; minimum outside air damper and mixed air damper.
  - The air handler mixed air damper controls to maintain a fixed mixed air temperature of 55 deg. F.
  - The air handler minimum outside air damper controls to maintain a CO2 setpoint of 1,000 ppm.
- Preheat control valve is commanded to a 100% open position at an outside air temperature enable of 45ºF (adj.).
- Relief air damper command tracks the mixed air damper command.
- Each AHU has an associated building/ space static pressure sensor. It is undetermined whether the return air fan or relief air damper has any control to maintain building static.
- The morning warm-up is enabled based on an Outside Air Temperature setpoint of 40ºF (adj.).

Retro-Cx Measure #1
Optimize Economization Operations

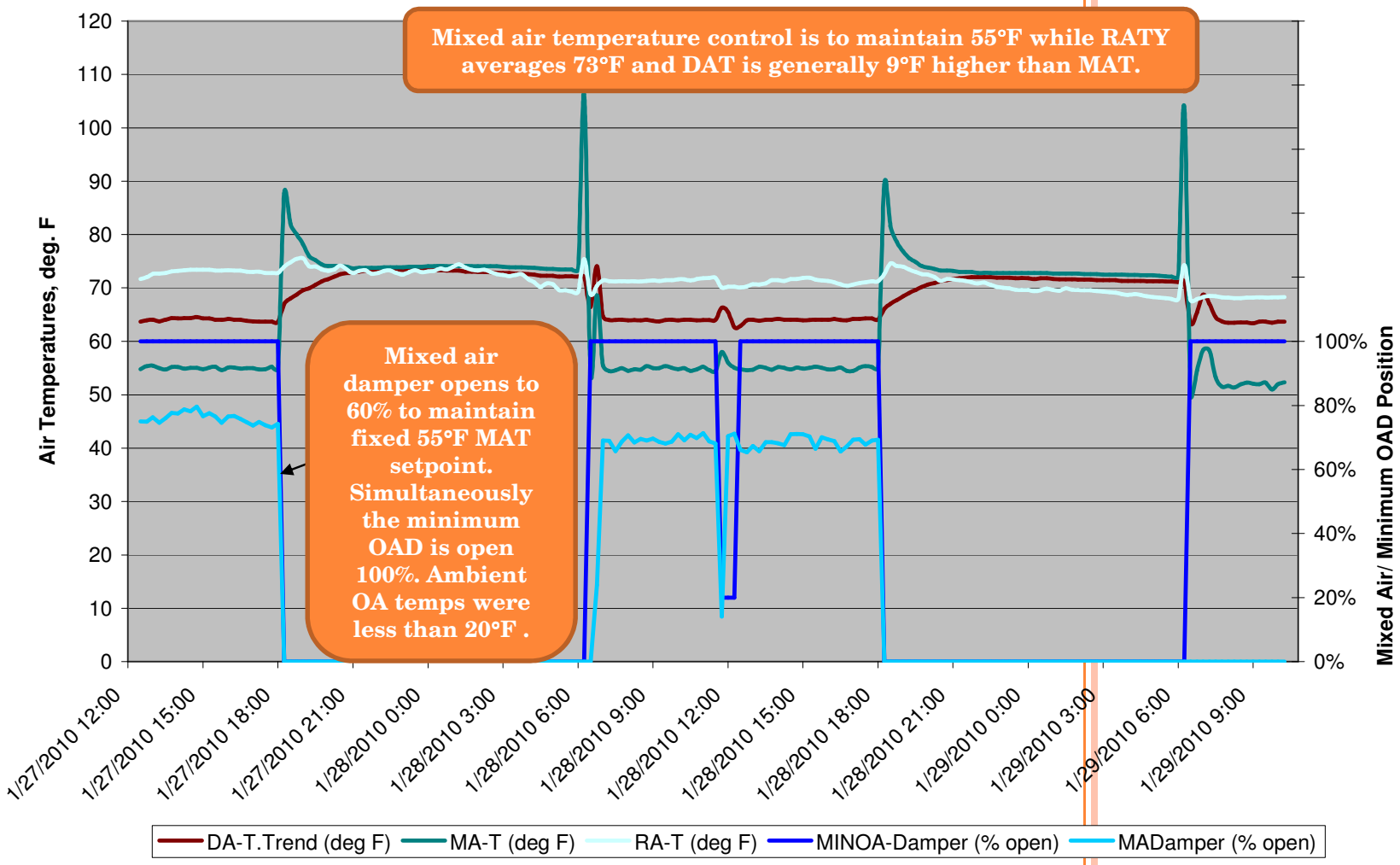
Observations:

- When TEMP-ECON is ON and ENTH-ECON is OFF, the mixed air dampers modulate to maintain mixed air temperature setpoint.
- When TEMP-ECON is OFF and the ENTH-ECON is ON, the mixed air damper command is closed.
- Enthalpy control capability is not active.
- Economization control is dry bulb only
- Economization is only active from a 55ºF outside air temperature and less.

Proposed Modification:

- Modify economizer control to use the enthalpy comparison for economization.
- Modify the Dry Bulb control to be a comparison between RAT and OAT (less 2ºF).
- Raise the economizers dry bulb setpoint from 55ºF outside air temperature to 67ºF.

Retro-Cx Measure #1
Optimize Economization Operations



Retro-Cx Measure #2
Modulating pre-heat control

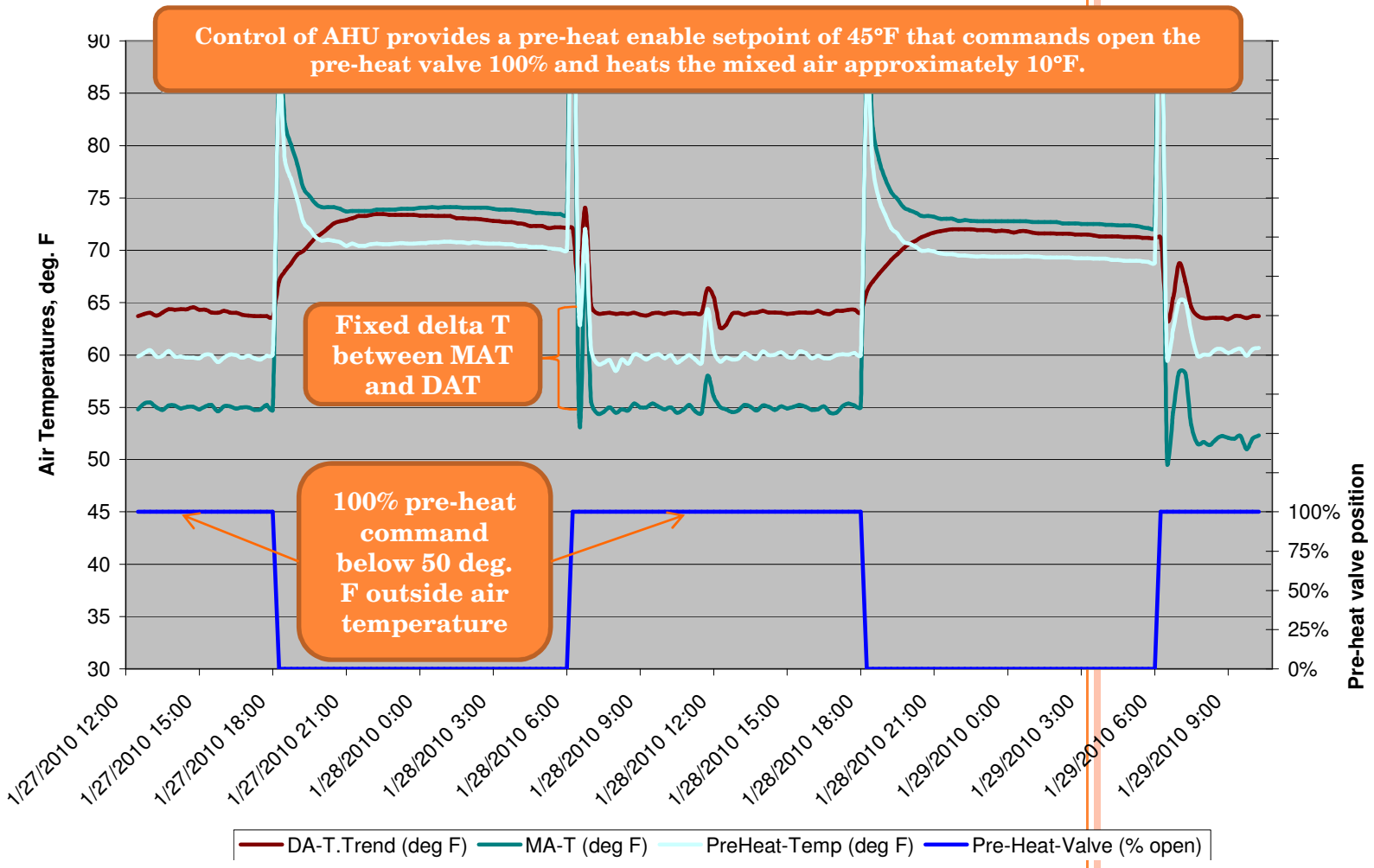
Observations:

- The preheat control valve is enabled at an outside air temperature setpoint of 50ºF.
- At the outside air enable temperature condition, the pre-heat control valve is commanded to a 100% open position.
- Taking control of the pre-heat valve will provide finer temperature control capability.

Proposed Modification:

- Modify control sequencing to reset the pre-heat air temperature setpoint to maintain 1 deg. F below the discharge air setpoint.
- Modify the control logic to provide PID control of the pre-heat control valve.
- Reduce the pre-heat enable setpoint to 45ºF.

RETRO-CX MEASURE #2
MODULATING PRE-HEAT CONTROL



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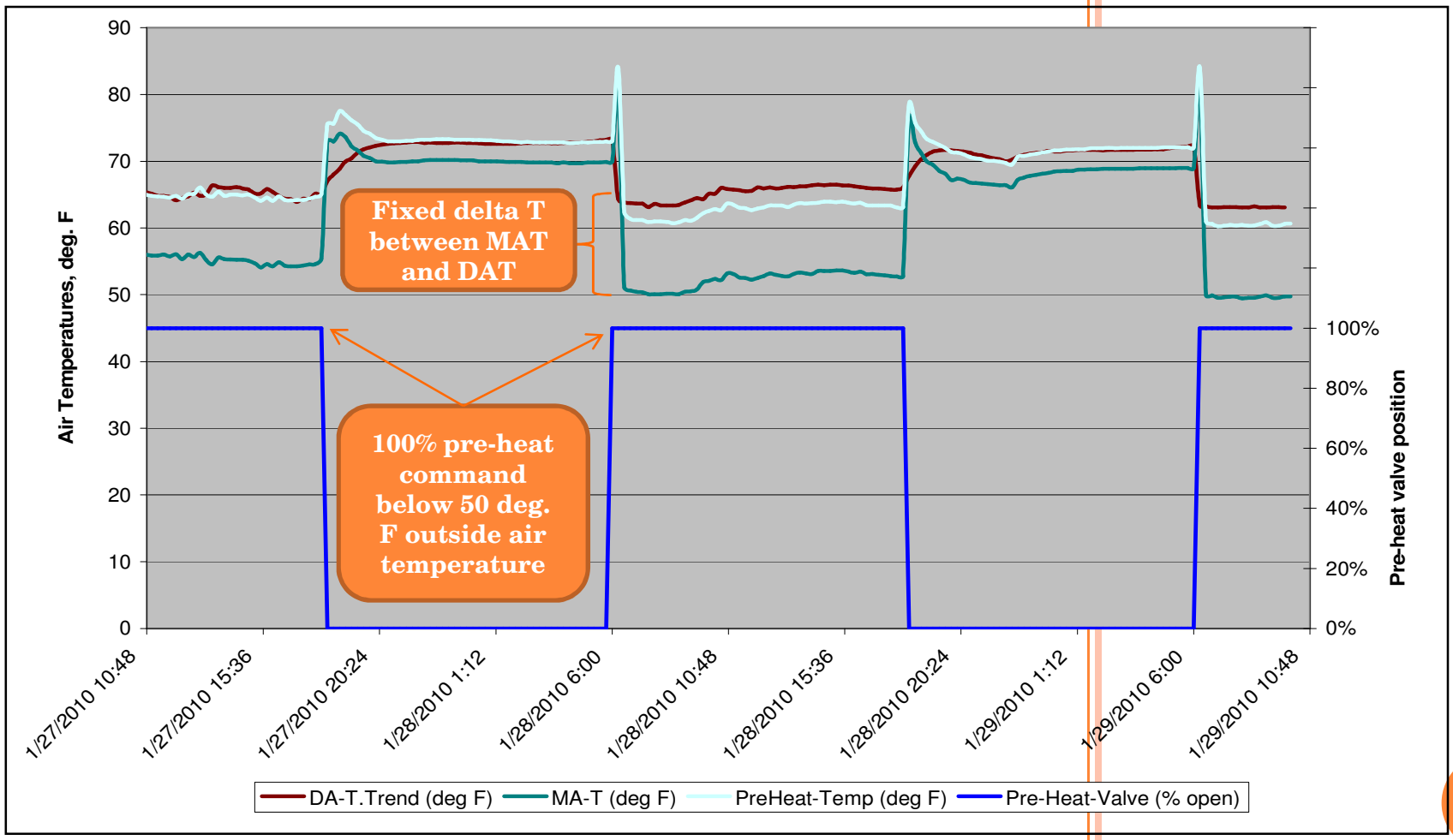
Retro-Cx Measure #2
Modulating pre-heat control



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Retro-Cx Measure #3
Mixed Air Temperature Reset

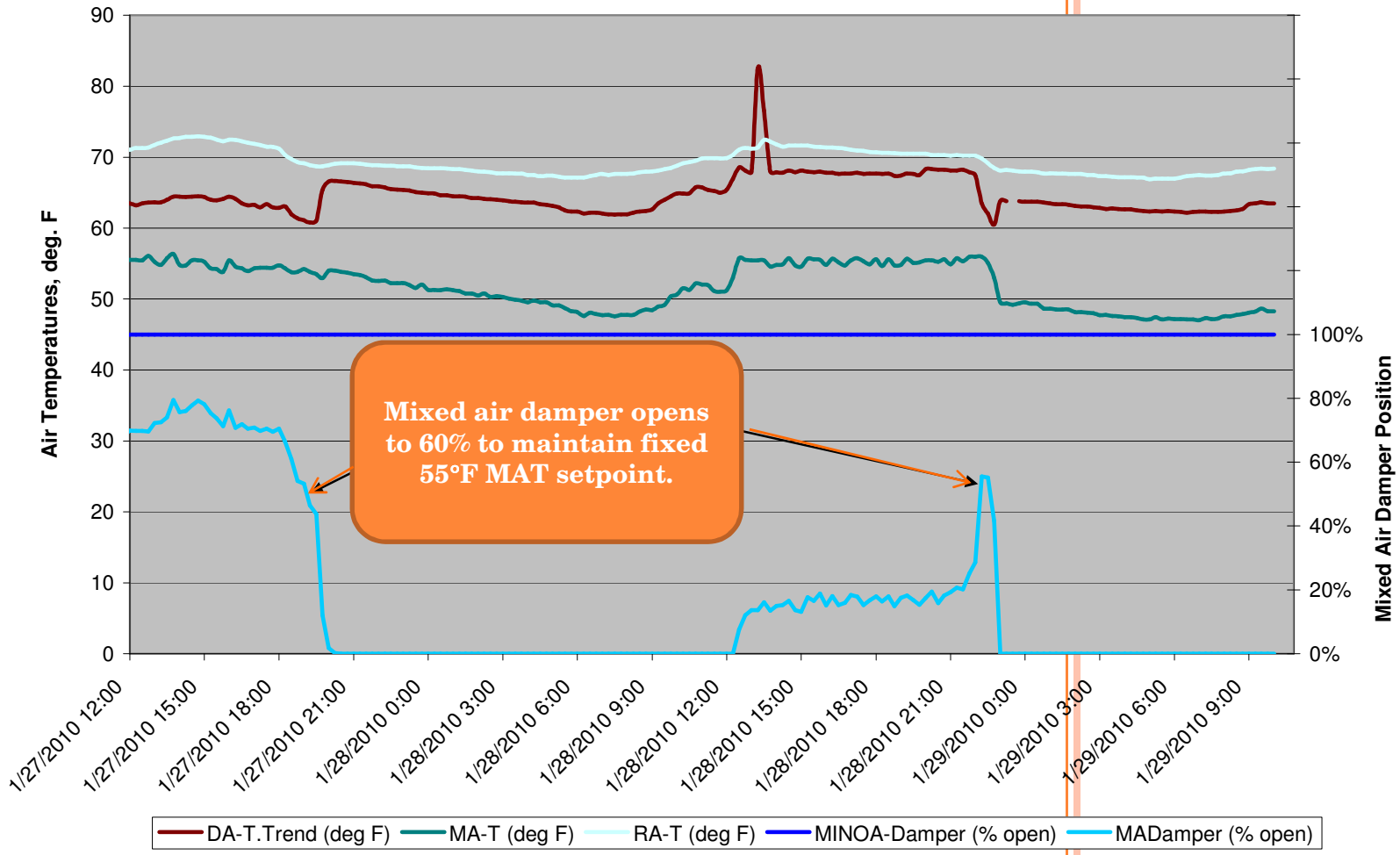
Observations:

- Mixed air temperature controls to maintain 55ºF while RAT averages 73ºF and DAT is generally 13ºF higher than mixed air.
- Mixed air damper modulates to maintain a fixed 55ºF mixed air temperature setpoint
- Minimum OAD is simultaneously open to a 100%
- During the trending period the ambient outside air temperatures were generally less than 20ºF.
- The fixed mixed air temperature is intended to supplement economizer control.
- A fixed mixed air temperature places an excessive heating load and unnecessary steam usage on the pre-heat coil as it gets colder outside.
- As is gets cooler outside there needs to be a means to exit economization .
- With100% a pre-heat command on the pre-heat coil resulting in a 64ºF-66ºF discharge air temperature through the current inefficient pre-heat control, then it is assumed that temperature is adequate for discharge air temperature delivery.

Proposed Modification:

- Provide a mixed air reset strategy to set the mixed air setpoint to be 1ºF less than the discharge air temperature.
- The modified mixed air temperature setpoint should allowing the mixed air damper to control and track to the discharge air temperature along with a modified discharge air reset control strategy.
- This control strategy will force the mixed air damper control to a more closed position during colder ambient conditions and reduce air handler heating loads.

Retro-Cx Measure #3
Mixed Air Temperature Reset



RETRO-CX MEASURE #4
CO2 CONTROL ON MINIMUM OAD

Observations:

- Air handling unit(s) each have return air mounted CO_2 sensors. Trend logs and random checks show CO2 in the order of 500-600 ppm (Occupied).

- Unoccupied CO_2 level of approximately 420 ppm.

- Metasys has a 1,000 ppm CO2 setpoint.

- During all operating conditions, the minimum outside air damper remains 100% open.

- Based on the trend logs and visual observations, the demand control sequence of operation is inactive.

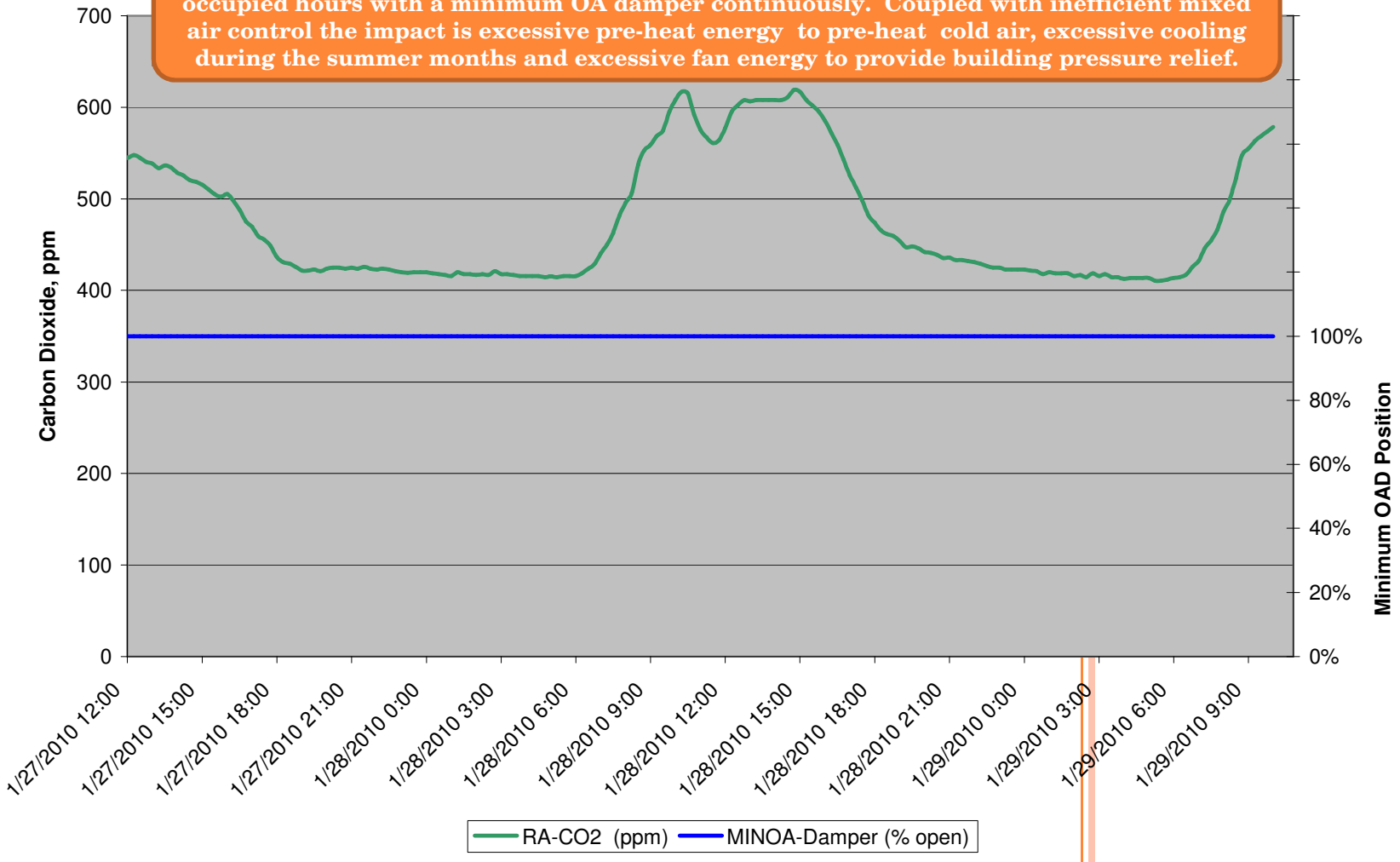
- Reductions in ventilation airflow delivery through effective CO_2 control will facilitate decreased cooling and heating loads during non-economization and mixed air modes of operation.

Proposed Modification:

- Provide a functioning CO_2 control sequence that will modulate the minimum outside air damper position in order to maintain CO_2 setpoint during non-economizer modes of operation.

Retro-Cx Measure #4
CO2 control on minimum OAD

The CO2 setpoint is 1,000 ppm. Trend log demonstrates a maximum level of 580 ppm during occupied hours with a minimum OA damper continuously. Coupled with inefficient mixed air control the impact is excessive pre-heat energy to pre-heat cold air, excessive cooling during the summer months and excessive fan energy to provide building pressure relief.



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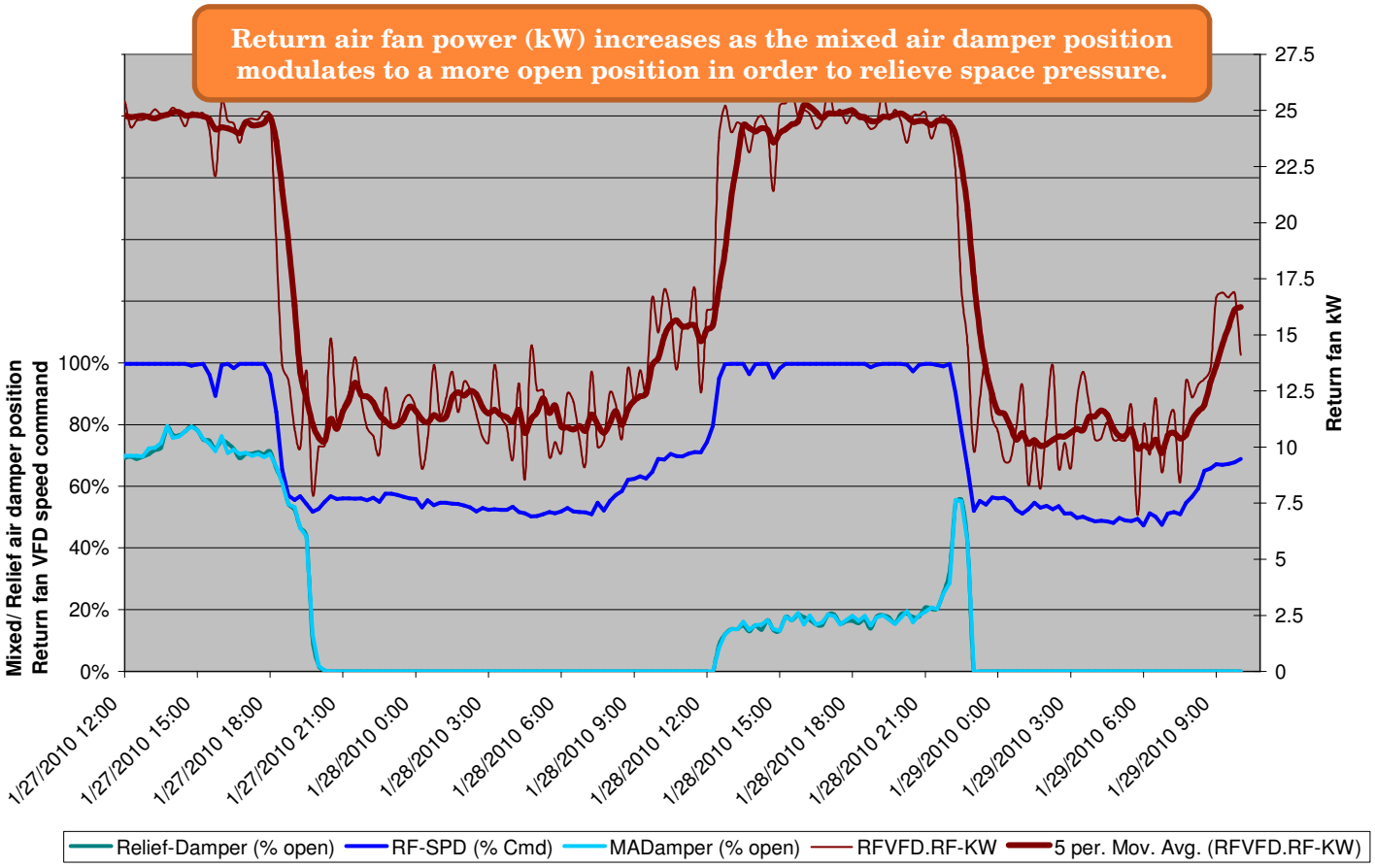
IMPACT OF EXCESSIVE OUTSIDE AIR ON RELIEF FAN SPEED AND POWER CONSUMPTION

Observations:

- Increased in outside air through the mixed air dampers has a direct correlation to relief fan speed and power consumption.
- Modified mixed air control as described in in Retro-Cx Measures #3 and #4.



Retro-Cx Measure #5
Discharge Air Temperature Reset

Observations:

- The discharge air temperature setpoint for the air handlers is a fixed 58ºF.

- During functional testing of the air handling units, it was noted that the chilled water valve closed and the pre-heat valve full open that the measured discharge air temperature was 64-66ºF.

- The sequence of operations locks out the chilled water valve based on outside air temperature.

- The objective should be to use the mixed air dampers more efficiently to maintain a mixed air/ discharge air temperature condition.

Proposed Modification:

- Provide a discharge air temperature reset strategy based on outside air temperature or zone feedback

- Maintain the current chilled water valve lockout.

- The discharge air temperature reset is necessary for successful operation of the mixed air control strategy described in Observation 3.

RETRO-CX MEASURE #6
MODIFY VAV SETPOINT CONTROL

Observations:

•Typical zone temperature "Common Setpoint" on the Johnson control interface is 72°F. with a deadband of 4°F,

•The zone thermostats are Johnson Control NS-BTN700x model temperature only wall mounted devices with a Warmer/Cooler adjustable dial that provides tenants with temperature override capability.

•All zones are provided the ability to adjust the Common Setpoint +/- 5.0°F. The Warm/Cool Adjust adds/subtracts the received local adjustment to the deadband built into the heating/cooling control as described above.

•If a local adjustment is made through the dial to set the warm/cool adjust parameter to the full -5.0°F swing; the maximum cooling setpoint will adjust to 69°F with an effective setpoint of 67°F placing an excessive cooling load on the system and forces the air handling unit to work harder to maintain duct static pressure.

Proposed Modification:

•Objective should be to modify the override capability in the zones to prevent wide swings in VAV operations and uncontrollable air handler fan speeds.

•Alternate A

- •Develop a group of 2-3 zone based Warmer/Cooler Adjust limits for each of the zone types.
- •Interior zones might be provided with the maximum flexibility of a Warm/Cool Adjust of 2°F.
- •Exterior and conference spaces might be provided with and limited to 1°F adjustments to temperature.
- •Corridors and common areas might be provided with no adjustment ability.

•Alternate B

- •Remove all override capabilities within the building.
- •Track complaints and provide 1-2°F increments on Warm/Cool Adjust based on those complaints to facilitate limited, direct control by the tenants.
- •Establish rules for the maximum allowable Warm/Cool Adjust parameters.

Retro-Cx Measure #7
Static Pressure Reset

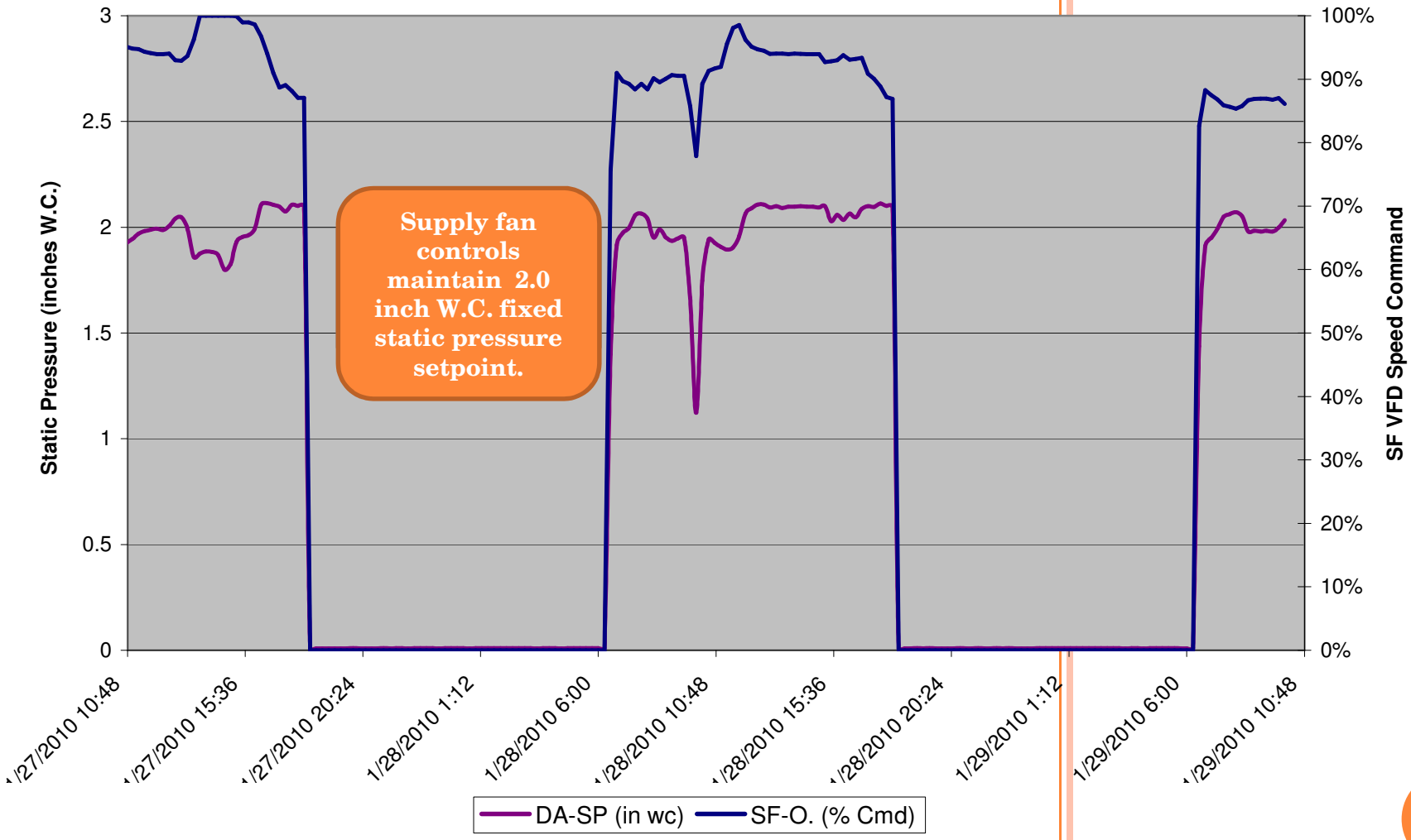
Observations:

- During cold outside air temperatures VFD speeds on several air handling units operate in the range of 90% to 100%.
- Typical VAV operation is expected to modulate to a minimum position during moderate and heating modes of operation with reduced supply air fan speed and power consumption.
- Frequent period of supply fan speed greater than 90% and for a period at 100% speed are observed.
- High motor power consumption at higher supply and return fan operating speeds/ flow rates. The return fan is controlled to maintain a fixed airflow differential from the supply fan.
- Any means implemented to reduce supply fan speeds and motor usage will have a correlating reduction in return fan speeds and power usage.

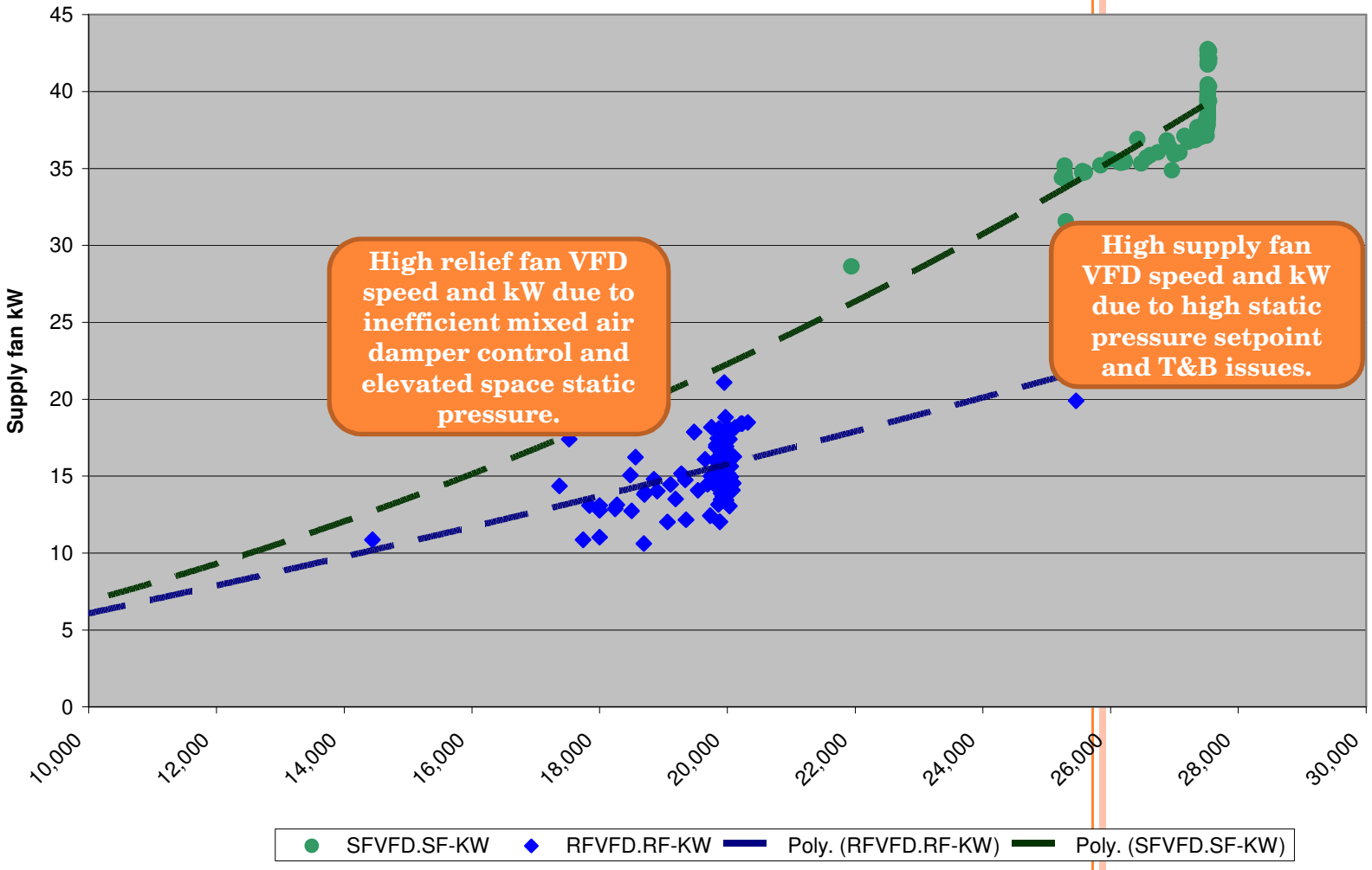
Proposed Modification:

- Have a T&B technician review the set-up and establish an appropriate static pressure setpoint.
- Verify sensor locations and move down to 2/3 down longest duct and relocate, if necessary.
- Implement supply static pressure reset function based on zone VAV conditions.
- Balancing system air flow requirements to match the zone level airflow requirements should be the objective of an efficient air delivery system. Static pressure reset will help facilitate this objective.

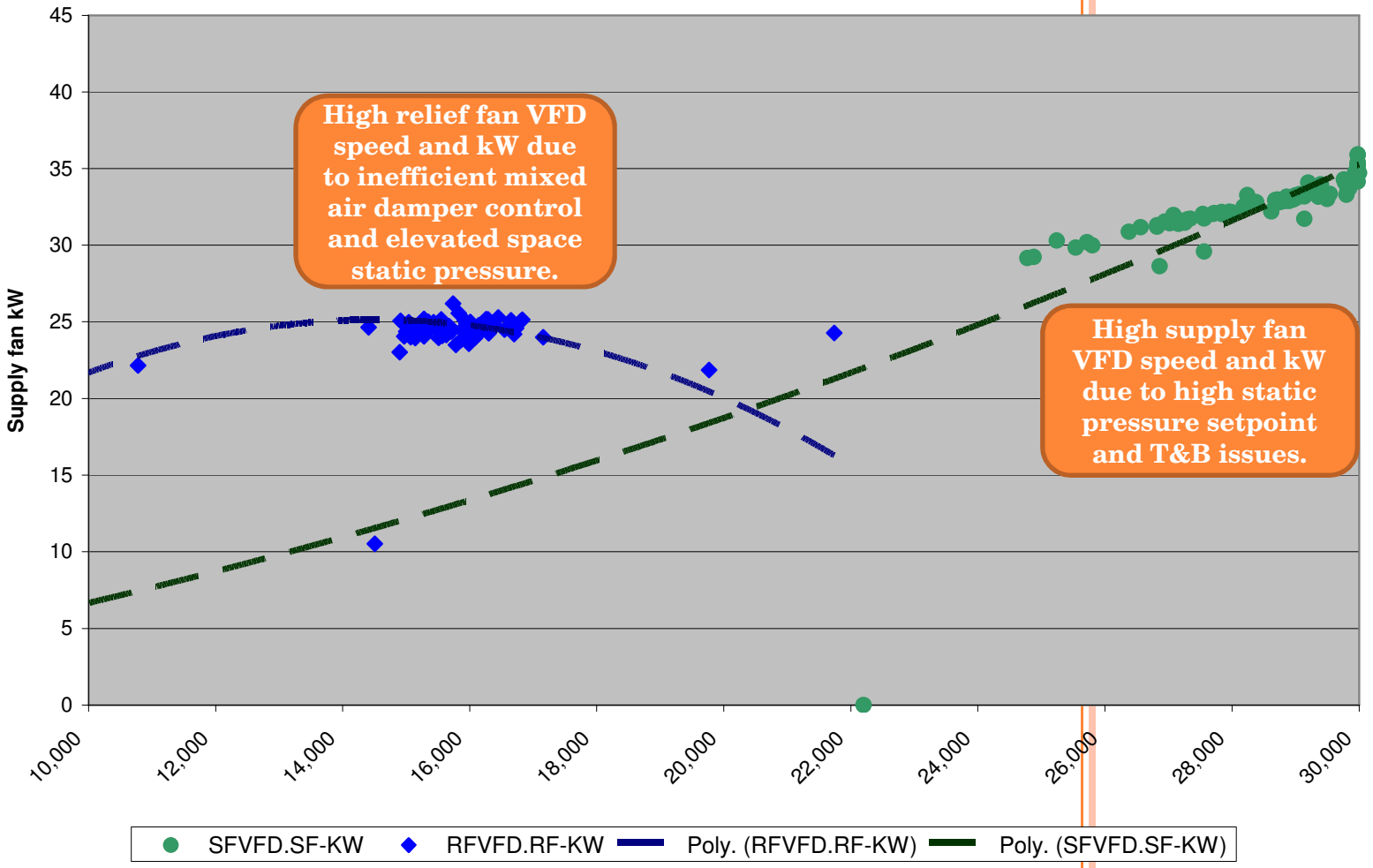
Retro-Cx Measure #7
Static Pressure Reset



Retro-Cx Measure #7
Static Pressure Reset



Retro-Cx Measure #7
Static Pressure Reset



Retro-Cx Measure #8
Test & Balance

Observations:

- Supply fan airflow for AHU-3W was measuring 29,980 cfm to maintain 2.0 inches.

- Fixed offset value is -6740 cfm establishing a return airflow setpoint of 23240 cfm.

- Actual return fan airflow at the DDC was measuring 10,870 cfm (12,370 cfm differential).

- Upper Figure shows the operating characteristic for the supply and return fan with supply fan operating in the area of 70% speed and return fan operating at 100% speed.

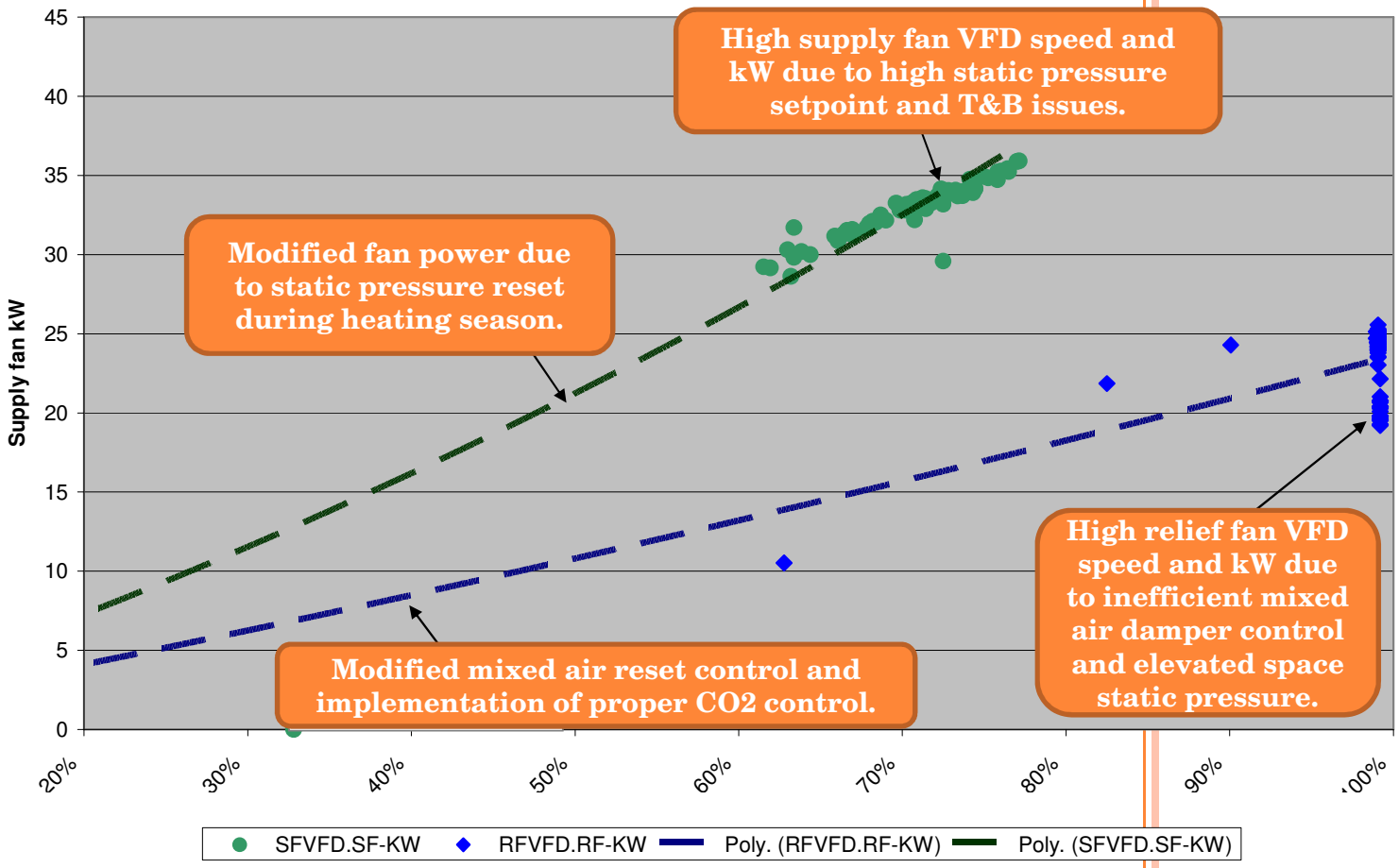
- Lower Figure shows the fan kW versus CFM. The capacity of the return fan is limited to provide any additional airflow to maintain the required offset between the supply and return fan.

Proposed Modification:

- The issues observed with airflows may have to do with the balance and setup of the fan(s) and/or sheave settings between the fan and the motor.

- In addition, to the balancing requirements associated with RCX #2, it would be of value to rebalance the air handling units along with the sequencing changes.

Integrated Impact of Retro-Cx Measures #3, #4 and #7



Retro-Cx Measure #9
Calibrate Outside Air Temperature Sensor

Observations:

- The outside air temperature sensor is deviated from an independent measurement by 10°F.

- Chilled water valve lockout is controlled based on outside air temperature.

- Pre-heat control is controlled based on outside air temperature.

Proposed Modification:

- Calibrate or replace outside air drybulb sensor in order to provide the proper feedback for chilled water valve lockout and pre-heat valve enable/ disable.

ECONOMICS OF RETRO-COMMISSIONING

Retro-Commissioning Measure		Utility Savings			Cost Savings				Cost	Payback
		Energy (kWh)	Steam, MMBtu	Chilled Water, ton-hr	Electric ($)	Steam ($)	Chilled Water ($)	Total ($)		
RCX #1	Optimize Economization	-	-	136,220	$ -	$ -	$ 13,030	$ 13,030	$ 7,500	0.6 years
RCX #2	Modulating Pre-Heat Control	-	300	-	$ -	$ 3,279	$ -	$ 3,279	$ 5,000	1.5 years
RCX #3	Mixed Air Temperature Reset	-	280	-	$ -	$ 3,070	$ -	$ 3,070	$ 5,000	1.6 years
RCX #4	CO2 Control on Minimum OAD	-	200	62,330	$ -	$ 550	$ 1,050	$ 1,600	$ 5,000	3.1 years
RCX #5	Discharge Air Temperature Reset	75,000	-	-	$ 3,510	$ -	$ -	$ 3,510	$ 5,000	1.4 years
RCX #6	Modify VAV Setpoint Control	75,000	100	5,000	$ 3,510	$ 1,090	$ 480	$ 5,080	$ 5,000	1.0 years
RCX #7	Static Pressure Reset	133,540	60	59,350	$ 6,240	$ 4,910	$ 5,330	$ 16,480	$ 5,000	0.3 years
RCX #8	Test & Balance of AHUs	-	-	-	$ -	$ -	$ -	$ -	$ 10,200	N/A
RCX #9	Outside air temperature sensor	-	100	25,000	$ -	$ 1,093	$ 2,393	$ 3,486	$ 3,500	1.0 years
RCX #10	Commissioning of systems	-	-	-	$ -	$ -	$ -	$ -	$ 16,250	N/A
Total		**283,540**	**1,040**	**287,900**	**$ 13,260**	**$ 13,992**	**$ 22,283**	**$ 49,535**	**$ 67,450**	**1.4 years**

Conclusions & Final Observations

1. System operational or control deficiencies can have an integrated response on other system control sequences.
2. Understanding the overall process of control of all of the system sequence of operations provides an overall system corrective strategy.
3. All of the measures identified in this case study had the potential to provide $49,535 in savings at cost of $67,450, including re-sequencing, test & balance and commissioning verification for 1.4 year payback period.
4. Retro-Commissioning existing controls provides the best means for system performance enhancements with the best payback scenario.
5. Following all retro-commissioning measure implementation activities it is imperative that the system upgrades be properly commissioned.