Owner Assistance
HVAC Modification
Implemention Results

for

Beecher Road Elementary School
40 Beecher Road - South
Woodbridge, CT 06525

Prepared for:

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Executive Summary

In September of 2018, van Zelm Heywood & Shadford, Inc. (van Zelm) was hired to provide Engineering Consultation Services for evaluating and troubleshooting the cause of ongoing humidity issues within the classrooms of the school.

In November of 2018, van Zelm provided a report that included our findings and recommendations. The school elected to proceed with the recommendations.

van Zelm developed design drawings in March of 2019 and at the end of school in June of 2019, United Control Solutions performed the work to allow for the implementation of the recommendations. New sensors were installed, and programming was added to allow for a revised sequence of operations.

It was mutually agreed that the work would be done in phases. This approach would allow two sections of the school, one with unit ventilators and one with fan coils, to be modified first. This would allow for an evaluation of the effectiveness of the measures before proceeding with modifications to other sections of the building.

The main humidity complaints were related to rooms served by Unit Ventilators and Fan Coil Units. The Fan Coils are served by roof top Energy Recovery Ventilating Units and the four ERVs were also modified to allow for full building automation control.

The major contributing factor for the inability of the HVAC system to provide reasonable dehumidification was determined to be the fact that the equipment has excess cooling capacity which results in the temperature setpoint being satisfied too quickly, which stops the cooling process and consequently the dehumidification process before the room has been adequately dehumidified.

The second leading factor was found to be the introduction of unconditioned fresh air during periods when the units are not calling for cooling.

The purpose of this report is to describe the post implementation evaluation process and provide information that will allow the school to make an informed decision to make further implementations to the remaining Unit Ventilators and Fan Coil Units.

Since the time of our preliminary report on August 1, 2019, the school elected to wait on performing additional work in the other classrooms. One reason was that the work could not be completed quickly enough to be beneficial this season. We all agreed that this would also allow for the occupants to weigh in on the results of the test areas. We hope to have feedback from the building occupants (since the beginning of the school year) as to the perceived effectiveness of the measures that have been implemented, however, the weather has not been very hot and humid.

Statement of Findings

Based on our post implementation evaluation described within this report, we believe the improvement in the lowering of room relative humidity levels warrants consideration by the school to move forward with the modifications of the remaining Unit Ventilators and Fan Coil Units. The conditions of the test area rooms, though not always ideal, are much improved during the hot humid weather. During mild weather, the difference between the test area and the existing rooms is less noticeable. If the school district feels the improvements are acceptable, van Zelm fully supports implementing the measures in the remaining areas served by unit ventilators and fan coils.

Original Recommendations for Implementation

The recommendations identified below are the original recommendations and were the result of our initial inspections and testing of a small sampling of the systems that feed the classrooms.

Each recommendation has been updated for this report to reflect the perceived effectiveness after implementation.

1. Classrooms with Unit Ventilators (Humidity Corrections-Option 1)

The following steps are generally in order of simplicity and cost to implement.

Step 1. Fan Speed - Recommend air flow reduction as a first step. Since the fan motors are PSC 3 speed motors, set the motors to low speed. Ensure the speed cannot be changed during this test period.

The fan speeds of the unit ventilators have been reduced to low speed. This has not had the impact we had hoped for, but no further reduction is possible with the installed motor. The room humidity levels would be further reduced if further fan speed reduction or air flow reduction were possible. We are now using the face & bypass damper position to further achieve an increased level of capacity reduction to compensate for the higher than desired airflows.

Step 2. Reset Chilled Water Temperature - Confirm the chilled water temperature setpoint. Try increasing the setpoint to 48˚F and monitor the results for not only the UV rooms, but the entire school to make sure other units like AHU’s and RTU’s are not negatively impacted.

These steps should be the first steps taken. If the elevated chilled water setpoint is problematic for other areas of the building, or the chilled water valve still modulates toward the closed position quickly, proceed to step 3.

The chilled water temperature was increased from 44˚F to 48˚F. This has had no negative affects on the other equipment in the building and has helped to increase the time the cooling valves remain open. The coils are still able to become saturated and provide dehumidification at this elevated temperature. An unforeseen benefit from the increase in chilled water temperature is the reduction, school wide, in condensation leaks on ceiling tiles. The increased setpoint will also allow for energy savings for the chiller.

Step 3. Limit travel of control valve - Through the Honeywell BAS, limit the maximum opening position of the valves. This will de-rate the cooling capacity of the chilled water coil. By de-rating the capacity of the coil, the control valve will be required to remain open longer to provide cooling to the room. This added time of opening will allow the cooling coil to remain "saturated" longer to provide increased dehumidification. The amount each valve will need to be limited will need to be determined by monitoring the results. Note: The limitation must only be applied to the control valve while in the cooling mode. The valve must be allowed to open fully in the heating mode.

The valves have been given minimum and maximum limits to again, help them to remain open for longer periods of time which increases the dehumidification in each room. This seems to have made a difference. Additionally, the face and bypass dampers have been manipulated to try to reduce the cooling capacity of the unit while still allowing dehumidification. There is a delicate balance in reducing the cooling capacity to increase run time while still allowing the unit to provide adequate dehumidification.

Step 4. Outside Air Quantity Reduction / CO2 Control - This step is intended to reduce the amount of outside air brought into the building. The outside air required for ventilation and pressurization is the single largest contributor to introducing humidity into the building. Any outside air introduced to the building needs to be effectively dehumidified to remove moisture if the building is going to be comfortable. Therefore, any reductions in the amount of outside air will reduce the amount of moisture that needs to be removed from the air to make the building comfortable.

The implementation a CO2 based demand-controlled ventilation routine. CO2 is used as an indication of the level of occupancy or the number of people in the room. The amount of fresh air can be varied to maintain the required amount of ventilation air per person. While this will allow for a reduction of the outside air amount while the unit ventilator is running, the use of a CO2 sensor would also allow the UV fan to be cycled off when the room temperature is satisfied. This would eliminate the current scenario where the room temperature is satisfied and the cooling valve closes stopping any dehumidification, but the unit continues to introduce, now unconditioned outside air. Once the room calls for cooling or the new CO2 sensor calls for ventilation, the fan will start up. While the UV fan is off, no unconditioned moisture laden outside air is introduced into the room, which will result in lower relative humidity levels.

Programming has been provided to allow for this change in the sequence of operation. This has been very beneficial in the reducing the relative humidity levels.

Classroom Exhaust - Now that the quantity of outside air has been reduced and UV fans are cycling on and off, the exhaust air quantity must be considered and addressed. This is important so that the building pressure remains under control and maintains a slight positive pressure. Options for exhaust control in the rooms is as follows:

Option 1 - Install a motorized damper ahead of the exhaust fan and open the damper when building pressure requires. This will act as a building relief to control classroom pressurization. This first option assumes that the fan is off.

Option 2 - If it is determined that the building pressure is negatively affected by keeping the exhaust fan off, a variable frequency drive (VFD) should be installed on the fans to allow for control of the exhaust airflow from the classrooms. This would require the installation of the motorized damper detailed in option #1 above.

Option 3 - An expensive, but very costly option to control the room exhaust would be to install a motorized control damper. The dampers would be installed in each room and opened when the UV fans turn on. The exhaust fan speed would be matched to the total UV outside air volume for the area served, which would require the installation of a VFD described in Option#2.

We recommend implementing the low-cost options (starting with option 1) and then monitoring the system to confirm that building pressurization is proper. If it is, there will be no need to proceed further with the additional options.

The A Wing has been running with the exhaust fan off. This has been beneficial. However, when we tested the A Wing unit ventilators in economizer mode (the use of outside air for cooling), with the exhaust fan off, we found that beyond 50% damper open position, the classroom door would close but not latch. With the exhaust fan on, the door would close and latch with the damper 100% open. The doors latching is a priority and safety concern and the control system must be operated to allow the doors to latch.

We recommend that the exhaust fan be programmed to start if any unit ventilator damper is open to 50% or greater (adj.) The door closers may be able to be adjusted to allow the doors to close with a high damper open position.

There are three exhaust fans serving A Wing. The main exhaust fan serves the majority of A Wing. Classrooms A1-A6 and the six restrooms associated with those classrooms.

A smaller exhaust fan serves classrooms A7-A9. The two restrooms associated with these classrooms have a dedicated toilet exhaust fan.

During occupied hours, the toilets need to be exhausted. However, it would still be beneficial to keep the exhaust for the classrooms off.

We recommend that the exhaust ducting be modified so that classrooms A7-A9 are connected to the main exhaust fan with the other classrooms. The smaller fan can now become a dedicated toilet exhaust fan by disconnecting the toilets from the main fan and reconnecting them to the smaller fan. This may be most easily accomplished by running new round duct above the ceiling and transitioning to the now disconnected runs to each toilet.

The newly dedicated toilet exhaust fan could then run based on the occupancy schedule and be off when school is out for the summer and the now dedicated classroom exhaust fan can be cycled based on the damper position of the unit ventilators. This will be an effective and less costly solution than either of the options listed above.

2. <u>Classrooms with Fan Coil Units</u>

The use of an outside air volume reduction strategy to reduce the ERU fan speed would be an effective way to improve the relative humidity levels in the classrooms served by the FCU's. This would be the same strategy as described in the UV section, "Outside Air Quantity Reduction / CO2 Control". The use of CO2 monitoring would allow for the FCU to cycle off and the associated outside air and exhaust dampers to close when the space temperature setpoint is met.

The fan speeds have been reduced to low speed. Unlike the unit ventilators, the fan coil unit fan speed could be modulated by the Honeywell building automation system if that is ultimately determined to be beneficial.

As was done with the unit ventilators, the fans are now being cycled and the valve positions are being limited.

The dampers that control the ventilation air from the associated ERV has been adjusted to preliminary minimum positions to allow the correct ventilation air quantities.

We will be recommending a further change in the sequence with respect to the operation of the dampers that will be described later in this report. This will be to further enhance the dehumidification ability at the fan coil unit.

3. <u>Energy Recovery Units</u>

Currently the ERU's have localized controls to operate frost control, economizer and summer switchover modes. Since these are functions happening within the unit, they are not able to be seen or trended by the BAS. We highly recommend that these control functions be brought on to the BAS system to allow for better control and monitoring of the ERU's in both the heating and cooling seasons.

This has been implemented and now allows for the building operator to monitor the operation of the units. The units ran in bypass last summer and this change should prevent that from happening again.

We were able to reduce the fan speed of the test ERV, ERV 1 associated with the Test Fan Coil Units. This will reduce the amount of unnecessary outside air and save fan energy.

4. <u>Chilled Water System Operation</u>

As discussed in the previous section, we only had a limited amount of time to review the system during a peak summer load. We feel that further monitoring and investigation will be useful in refining the operation and performance of the variable flow chilled water loop.

Increasing the chilled water temperature setpoint has benefitted the chilled water system.

Even with the increase in the setpoint and the flow reduction steps in A and S Wings, the chiller operation has remained quite stable and the chiller is controlling to the setpoint very well without the need to cycle on and off which can sometime happen on capacity reduction projects.

The differential pressure control could be improved, and we will likely recommend a change in the next phase as to how that is controlled but at this point it is not impacting the ability of the system to dehumidify.

There is plenty of capacity in the chilled water system.

Implementation Methodology

After the decision to proceed with the recommended changes was made, the first step was to have United Control Solutions install the new sensors and any required wiring in the rooms and at the Energy Recovery Units.

UCS also modified the existing Honeywell sequence of operations so that the units would operate with the revisions developed by van Zelm.

Once the hardware and programming changes were complete, van Zelm then monitored and adjusted the units in the test phase one.

This took place over the next few weeks and began with basic functional testing of each piece of equipment. Once it was confirmed that the valves, dampers and fans would respond to the BAS commands, additional time was spent monitoring and adjusting each unit to determine the optimal settings for greatest reduction of the relative humidity levels.

This monitoring and adjusting has taken place throughout the month of July 2019. It is still ongoing to some degree, but we felt there was enough of a change to meet with the team so they could decide whether to move forward while school is still out or not.

The monitoring and adjusting has taken place almost every day including weekends. Much of this has been done remotely with onsite inspections as well. Only one small change can be made at a time and then time must be given to determine if the change was effective. This proved to be a time-consuming endeavor. Partially because the response of the Honeywell building automation system is very slow when connected remotely as compared to the speed while connected within the building.

We have compiled some trending data from the Honeywell system as well as some data from data recorders that we installed in a few rooms. We also have documented temperature and humidity levels that were recorded manually during remote monitoring and site visits. These can be found in Appendix A.

The hope in implementing the changes is obviously to reduce the relative humidity levels as much as possible. Relative humidity is as the name implies, relative to the amount of moisture that the air, under a given condition, can hold. As the temperature changes the relative humidity will also change.

Therefore, we prefer to use Dewpoint as a gage of the amount of dehumidification taking place. The dewpoint considers the relative humidity and the temperature in the room. It is the temperature at which moisture will condense out of the air. This would be the condition that would cause moisture to collect on walls or surfaces in the classrooms.

While any reduction in humidity would be welcome, our target at the outset was to try to maintain a dewpoint as close to 60˚F or below the majority of the time. This is towards the upper limit for comfort but given the severity of the humidity problem, we felt this would be a realistic goal to achieve using the installed system. This is the criteria we are using to determine how effective the measures have been.

New Findings and Recommendations

The modified rooms have shown improved relative humidity and dewpoint levels. Some rooms have responded better than others.

As part of our investigation, we inspected the outside of the building. During our walk around the perimeter of the school, we noticed evidence of water collecting at or near the building. This seemed to be quite severe in some cases. This is beyond our scope but it would be beneficial for the school to consider having this condition evaluated.

We also noticed that there is quite a bit of vegetation growing at the fresh air inlet louvers for many unit ventilators. Some of the plantings seem as though they may be incorporated into the teaching curriculum. The vegetation may be contributing to the high levels of humidity. In fact , there is a pond at the base of one of the louvers.

We are sensitive to the care given to these plants and the appreciation they may have throughout the student and teacher population so at this point we are not ready to recommend they be removed.

The rooms in question are A7, A2, B1, B3, B5, B6, B4, B2, C5, C3, C2, C4 and C6.

The entire school is very cool. The average temperature is typically below 72˚F. The different areas of the building seem to influence each other, and it was more difficult than anticipated to isolate the two test areas. The doors of one wing or room being open is a “real world condition” so we worked as best we could under that condition.

The Gym, for instance, is open and can influence the temperature in the A Wing. The Gym was much to cool during this test period and may have reduce the required run time of the unit ventilators. Again, this is the real condition that the building will be operating so it is just another obstacle to overcome.

Our scope was working with two sections; A Wing with unit ventilators and a portion of S Wing with fan coil units. However, we did need to monitor the other systems as part of our chilled water system investigation and also because we increased the chilled water temperature setpoint.

All indications are that the other systems also have greater capacity than is currently required to cool the building. Some of these units could easily have their capacity reduced.

We believe that a recommissioning effort of those systems would allow for improvements that would benefit the entire school as well as provide further energy savings.

RTU 1 was found to have the heating water piped to the cooling coil and the cooling water piped to the heating coil. This results in inadequate cooling and potential overheating. The valves should be changed to the opposite coils.

We noticed that all three boiler isolation valves were open, and the micro turbine was operating. This condition is likely wasting energy and could be revised with further investigation.

There are also containers of glycol in the boiler room. The mechanical schedule did not call for glycol in the dual temperature loop. It has been confirmed that the glycol is used only to winterize the air cooled chiller and is not circulated through the system. van Zelm took a water sample on August 15, 2019 and tested the loop on August 19, 2019. The freeze point was measured at 32.4˚F indicating no propylene glycol. The PH was measured at 5.47 which is slightly acidic. We recommend the water loop be tested by a water treatment specialist.

We would also like to revise the fan coil outside air and exhaust air damper sequence to incorporate a demand controlled ventilation sequence similar to the unit ventilators. It was explained that the programming was in place and just needed to be implemented.

Some of the unit ventilator coil temperature sensors are not installed in the correct locations and should be relocated. They are in rooms A1, A4, A5, A6, A8

Rooms S16 and S12 were found to have voids in the building envelope above the ceiling above the outside door. There has been some insulation removed and no vapor barrier. This is allowing the ceiling space to communicate directly with the outdoors through the vented soffit of the building. These rooms have been repaired by the school but we recommend all rooms be inspected.

Appendix A
Data Trends

Honeywell Building Automation System Trending A Wing Modified Unit Ventilators From July 20, 2019 to July 30, 2019								
	UV_A1_RH(%)	UV_A1_T(°F)	UV_A2_RH(%)	UV_A2_T(°F)	UV_A3_RH(%)	UV_A3_T(°F)	UV_A4_RH(%)	UV_A4_T(°F)
Maximum	68.87	73.62	65.04	73.90	62.21	73.23	64.56	73.39
Average	64.07	72.69	60.48	72.89	59.70	72.49	60.36	72.69
Minimum	60.06	71.68	56.42	71.92	57.44	71.24	57.02	71.72
Average Dewpoint	59.70		58.30		57.60		58.10	
	UV_A6_RH(%)	UV_A6_T(°F)	UV_A7_RH(%)	UV_A7_T(°F)	UV_A8_RH(%)	UV_A8_T(°F)	UV_A9_RH(%)	UV_A9_T(°F)
Maximum	68.87	73.62	65.04	73.90	62.21	73.23	64.56	73.39
Average	64.07	72.69	60.48	72.89	59.70	72.49	60.36	72.69
Minimum	60.06	71.68	56.42	71.92	57.44	71.24	57.02	71.72
Average Dewpoint	59.00		60.70		60.80		61.10	

Honeywell Building Automation System Trending S Wing Fan Coil Units From July 25, 2019 to July 30, 2019								
	FCU2_S1 Space_RH (%)	FCU2_S1 Space_T (°F)	FCU3_S2 Space_RH (%)	FCU3_S2 Space_T (°F)	FCU6_S3 Space_RH (%)	FCU6_S3 Space_T (°F)	FCU7_S4 Space_RH (%)	FCU7_S4 Space_T (°F)
Maximum	65.50	72.00	66.35	72.05	70.90	71.73	70.08	71.82
Average	59.33	70.73	60.04	70.72	64.98	70.60	63.62	70.64
Minimum	54.66	69.87	55.12	69.92	60.72	69.87	59.20	69.95
Average Dewpoint	55.80		56.10		58.20		57.70	
	FCU18_S12 Space_RH (%)	FCU18_S12 Space_T (°F)	FCU4_S14 Space_RH (%)	FCU4_S14 Space_T (°F)	FCU5_S16 Space_RH (%)	FCU5_S16 Space_T (°F)		
Maximum	65.50	72.00	66.35	72.05	70.90	71.73		
Average	59.33	70.73	60.04	70.72	64.98	70.60		
Minimum	54.66	69.87	55.12	69.92	60.72	69.87		
Average Dewpoint	57.00		56.60		58.70			

HOBO Data Recorder S Wing FCU Modified to Existing Comparison July 24, 2019 to July 30, 2019												
	Modified S3			Modified S16			Existing S5			Existing S8		
	Temp	RH%	Dewpoint	Temp	RH%	Dewpoint	Temp	RH%	Dewpoint	Temp	RH%	Dewpoint
Maximum	72.35	68.54	60.80	72.22	74.65	62.10	74.55	82.69	68.71	74.94	83.06	69.00
Average	70.96	64.14	58.27	70.34	70.12	60.18	73.31	70.69	63.16	73.96	72.38	64.63
Minimum	70.20	61.98	57.31	69.77	67.12	58.53	71.88	59.85	59.09	73.21	61.28	60.52

HOBO Data Recorder A Wing Unit Ventilator Modified to Existing Comparison July 13, 2019 to July 24, 2019								
	Modified A8		Modifeid A4		Existing B1		Existing B2	
	Temp °F	RH%	Temp °F	RH%	Temp °F	RH%	Temp °F	RH%
Maximum	74.25	73.97	73.60	71.29	74.55	83.63	74.55	85.83
Average	71.90	68.14	71.82	67.74	73.07	76.79	73.26	75.79
Minimum	70.54	60.33	70.76	64.19	71.75	67.30	72.01	63.39
Average Dewpoint	60.80		60.60		65.30		65.10	

These values were measured with a hand held meter during a survey of the Existing Rooms														
			Measured Values				Measured Values				Measured Values			
Date	Time	Room	Temp	RH%	Dewpoint	Room	Temp	RH%	Dewpoint	Room	Temp	RH%	Dewpoint
7/17/2019	12:30 PM	B1	74.6	82.1	69	C1	73.9	59.9	59.1	S17	74.1	66.9	62.4
		B2	74.8	82.1	69	C2	71.6	83.4	66.2	S5	75	85.6	70.3
OA Temp	OA RH%	B3	74.3	84	69.2	C3	72.5	67.8	61.3	S6	74.3	85.7	69.6
91	52	B4	75.3	78.8	68.3	C4	73.5	81.1	67.2	S7	74.3	81.9	68.5
		B5	72.3	78.3	65.3	C5	73.7	77.5	66.3	S8	74.3	87.5	70.3
		B6	74.8	84	69.6	C6	74.1	84.8	69.1	Corridor	73.7	65.9	61.5
		B7	70.3	85.9	74.8	Corridor	73.5	65	61.1				
		B8	74.1	78.2	66.9								
		Corridor	73.9	78.5	66.8								

Beecher Road School A Wing Remote Monitoring and Adjustments

Date	Time	OAT	OARH		RH A1	Temp A1	RH A2	Temp A2	RH A3	Temp A3	RH A4	Temp A4	RH A5	Temp A5	RH A6	Temp A6	RH A7	Temp A7	RH A8	Temp A8	RH A9	Temp A9
7/9/2019					Changed chilled water temp from 44 to 48																	
7/13/2019	4:30 PM				Set valve min/max 40/50					SAT SP 64		RM SP 73										
7/14/2019	7:00 AM	77.00	65.00		66.50	71.40	67.50	72.90	43.30	72.40	62.70	71.90	66.80	71.60	65.70	71.80	69.20	70.80	70.40	71.00	69.07	71.40
	8:45 AM	86.00	53.70		66.20	71.80	65.30	72.87	44.10	72.60	62.70	72.00	66.50	71.70	66.10	71.90	69.40	71.00	70.50	71.20	70.10	71.60
	10:00 AM	89.80	49.00		66.50	72.00	65.30	72.50	44.60	72.90	63.10	72.20	67.20	71.90	66.70	72.10	70.30	71.30	71.60	71.30	71.70	71.20
	1:52 PM	94.20	39.10		67.30	72.60	62.70	72.70	46.80	72.00	63.40	73.40	67.70	72.50	66.70	72.90	72.60	72.20	73.90	72.20	73.20	72.40
	5:50 PM	90.80	37.90		67.40	72.90	59.80	72.50	46.30	71.80	59.10	71.80	67.89	72.70	62.75	72.40	73.10	72.80	74.60	72.80	73.00	72.80
	6:54 AM	88.00	41.99		67.20	72.50	59.60	71.90	45.90	72.40	59.30	72.80	67.90	72.70	67.90	72.70	73.00	72.80	74.60	72.90	72.90	72.80
7/15/2019	6:25 AM	68.20	67.90		66.40	72.20	63.20	72.20	44.00	72.40	61.90	72.10	67.00	71.80	65.90	72.10	70.60	71.20	71.70	71.70	69.30	71.70
	10:32 AM	81.50	51.00		64.70	72.50	59.00	72.69	44.50	72.20	61.10	72.20	65.47	71.90	63.90	72.20	69.00	72.40	68.10	72.50	67.10	72.20
	4:56 PM	87.50	39.50		64.20	73.00	58.10	73.00	43.80	73.00	58.00	72.80	65.20	72.50	62.40	72.90	62.30	72.20	62.60	72.80	66.50	72.60
7/16/2019					Adjusted A1																	
7/17/2019	5:38 AM	76.50	71.40		65.00	71.80	60.87	73.00	43.60	73.00	61.60	72.60	65.48	72.20	64.00	72.50	65.20	71.90	64.20	72.30	67.80	72.30
	9:29 AM	83.10	63.90		65.02	72.50	62.43	72.14	44.49	72.30	61.74	72.78	66.11	72.29	63.86	72.63	65.80	75.41	67.97	72.97	68.40	72.51
					Changed all units to 30% F&B					A3 shut off dehumidifier												
	12:04 PM	93.10	52.10		62.89	72.40	60.47	72.88	48.04	72.39	60.90	72.73	66.03	72.59	63.71	72.21	58.58	72.13	62.17	71.99	68.44	72.79
	2:46 PM	93.20	53.00		61.32	72.77	59.68	72.83	49.93	72.71	58.63	72.99	66.21	72.94	60.38	72.02	56.37	72.29	62.73	72.99	62.74	72.80
	6:43 PM	80.00	69.70		64.00	72.86	60.00	72.40	52.38	72.90	60.00	71.80	67.40	72.90	61.79	72.70	60.20	72.80	65.70	72.99	66.04	72.79
7/18/2019	7:26 AM	75.70	79.50		65.29	72.40	62.90	72.76	53.20	72.60	61.83	72.60	66.92	72.32	64.10	72.32	66.09	71.79	67.36	72.21	67.73	72.27
	1:50 PM	75.90	80.70		65.30	72.50	62.40	72.88	53.64	72.54	62.30	72.87	67.25	72.37	64.44	72.75	60.62	71.97	69.44	72.75	70.18	72.69
7/19/2019	7:30 AM	73.20	73.90		66.50	71.76	65.50	72.39	55.76	71.71	63.56	72.06	68.33	71.56	65.57	71.96	67.66	70.92	69.62	71.40	70.56	71.71
7/20/2019	7:25 AM	84.30	66.90		67.99	72.57	64.49	71.32	58.41	72.42	63.85	71.80	68.29	72.31	66.43	72.08	69.05	72.02	72.94	72.28	70.83	72.39
	3:36 PM	95.00	54.30		65.30	72.26	61.03	72.66	58.16	72.35	58.79	72.84	63.70	72.50	60.61	72.58	64.45	72.84	66.56	72.49	65.12	72.77
	6:40 PM	92.80	52.80		64.67	72.80	59.87	72.72	58.26	72.77	58.35	72.77	63.86	72.96	60.27	72.12	64.13	72.99	65.98	72.87	66.79	72.91
7/21/2019	9:24 AM	89.00	58.80		65.04	73.00	61.17	72.26	59.39	71.56	60.17	72.56	65.86	72.78	62.29	72.49	66.26	72.49	66.55	72.64	66.67	72.62
					Changed A1 F&B from 30 to 20													Changed A8, 9 F&B from 30 to 20				
	11:34 AM	92.30	54.80		63.73	72.67	61.36	72.09	58.79	72.09	59.77	72.91	66.21	72.96	61.38	72.90	66.93	72.73	67.65	72.81	67.01	72.86
	4:15 PM	97.30	47.50		60.91	71.16	59.06	72.26	57.64	72.96	57.11	72.74	61.44	72.98	58.66	72.70	62.00	72.88	61.95	72.91	63.62	73.00
	6:38 AM	96.00	49.10		60.43	72.10	58.44	73.00	57.38	72.94	57.49	72.42	60.28	72.81	58.76	72.96	60.35	72.96	60.19	72.97	62.56	72.83
7/22/2019	6:25 AM	74.60	67.10		63.90	72.39	61.15	72.26	59.82	72.28	60.82	71.83	64.55	72.05	63.00	72.09	65.04	71.97	62.89	71.87	65.69	72.71
														changed A5, A7 F&B from 30 to 20								
	11:42 AM	82.00	57.40		60.73	72.69	58.35	72.59	58.84	72.89	58.97	72.17	64.20	72.81	60.99	72.81	60.99	72.99	61.77	72.45	64.85	72.78
	7:55 AM	70.80	81.80		62.20	73.17	59.25	73.47	58.72	72.83	59.11	73.01	63.49	72.75	60.69	73.01	67.85	73.20	64.97	72.89	65.63	72.89
7/23/2019	5:33 AM	68.40	78.40		63.86	72.71	61.82	73.02	60.64	72.19	61.12	72.59	65.72	72.12	62.70	72.54	67.47	71.80	66.83	71.19	67.53	72.30
	4:48 PM	75.10	65.00		64.12	72.56	60.02	72.68	60.59	72.19	60.88	72.78	65.53	72.12	62.89	72.65	65.06	72.84	64.90	72.70	69.15	72.66

					RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp
Date	Time	OAT	OARH		A1	A1	A2	A2	A3	A3	A4	A4	A5	A5	A6	A6	A7	A7	A8	A8	A9	A9
7/24/2019	7:15 AM	69.10	76.00		64.20	72.01	61.01	72.29	61.50	71.68	61.48	71.97	66.61	71.64	64.18	71.91	69.05	71.17	68.16	71.49	69.86	71.68
7/26/2019	6:58 PM				Changed schedule to 24 hours																	
7/28/2019	6:25 PM	87.80	55.80		63.81	72.90	58.76	72.74	64.67	72.81	59.55	72.14	68.41	72.75	62.71	72.65	73.94	72.56	71.54	72.74	72.32	72.61
7/29/2019	2:17 PM	91.70	49.00		63.00	72.22	60.91	72.11	64.29	71.88	60.12	71.95	68.79	72.99	61.72	72.21	73.23	72.75	64.00	72.11	72.61	72.79
																	Changed A7,9 F&B from 20 to 30					
7/30/2019	1:11 PM	93.70	51.10		62.98	71.96	54.87	73.14	65.14	72.88	64.90	72.49	65.88	72.68	61.86	71.89	74.10	72.85	69.25	72.66	70.86	72.59
	7:20 PM	86.10	57.50		61.49	72.32			62.64	72.81	63.85	72.95	64.67	72.96	60.37	72.92	68.87	72.78	54.78	72.30	72.40	72.90
8/3/2019	3:17 PM	86.10	52.80		60.07	72.79			65.64	72.50	60.15	72.51	67.13	72.54	60.99	72.55	69.64	72.05	67.39	72.51	68.76	72.35
					Changed A5,7,8,9 SP from 73 to 71																	
8/4/2019	9:15 AM	84.10	53.90		59.76	72.59			66.85	71.71	62.14	72.55	60.28	70.43	63.71	72.39	67.19	70.57	68.04	70.91	70.28	70.94
	3:45 AM	91.60	42.80		58.11	72.89			65.77	72.19	58.79	73.00	56.83	70.35	59.69	71.89	63.47	70.95	60.89	70.10	64.26	70.06
8/5/2019	9:48 AM	77.60	48.20		57.89	72.81			64.59	71.53	60.07	72.39	60.31	70.38	61.55	72.27	63.53	70.42	59.79	70.84	59.73	70.91
8/7/2019	2:00 PM	86.70	55.50		59.13	72.88	58.52	72.56	67.11	71.54	62.92	72.87	60.20	70.41	64.40	72.75	71.98	70.97	67.36	70.77	69.85	70.62
8/13/2019	5:03 PM	76.40	72.40		65.30	72.38			62.89	72.43	60.42	72.63	59.03	70.01	60.94	72.97	69.41	70.22	67.50	70.62	66.70	70.88

Beecher Road School S Wing Remote Monitoring and Adjustments

Date	Time	OAT	OARH		RH S4	Temp S4	RH S3	Temp S3	RH S16	Temp S16	RH S14	Temp S14	RH S2	Temp S2	RH S1	Temp S1	RH S12	Temp S12
7/9/2019					changed chiled water temp from 44 to 48													
7/17/2019	5:38 AM	76.50	71.40		60.20	71.70	62.60	71.20	60.30	71.80	56.30	71.80	59.90	72.00	57.60	72.30	58.40	72.90
					adjusted fan speeds to low					Dampers to 100			V min/max 40/50			SP 72		
	6:43 PM	80.00	69.70		63.30	72.10	64.85	72.05	68.61	71.89	61.07	72.56	67.18	72.25	65.30	72.30	64.95	72.75
7/18/2019	7:36 AM	75.70	79.50		65.68	71.51	67.13	71.32	69.08	71.50	64.50	71.83	67.20	71.57	65.39	71.60	63.99	71.34
	1:58 PM	75.90	80.70		69.05	71.82	71.63	71.78	76.00	71.91	63.37	71.40	74.17	71.89	69.35	71.77	66.40	71.36
7/19/2019	7:40 AM	73.20	73.90		71.37	70.70	73.32	70.23	72.63	70.56	64.55	71.32	73.00	70.94	70.59	71.30	66.96	71.67
7/20/2019	7:16 AM	84.30	66.90		68.26	71.40	71.93	71.11	72.04	71.49	64.23	72.00	70.22	71.09	66.24	71.03	64.47	72.40
	3:20 PM	94.60	54.40		73.50	71.30	71.58	71.86	83.14	72.39	74.29	71.38	77.24	71.62	71.43	71.90	68.46	72.52
					chamged SP from 72 to 71					Changed max V from 50 to 70								
	6:23 PM	93.40	52.90		73.23	70.67	71.02	71.34	79.00	71.54	68.61	70.83	71.73	70.77	65.99	70.10	65.74	71.95
					Changed ERV 1 SP SP from .5" to .25"													
7/21/2019	9:10 AM	89.90	58.40		63.00	70.87	65.98	70.93	73.34	70.08	64.34	71.13	67.23	70.02	63.04	70.53	65.50	71.66
					Changed S16 V from 70 to 100					Changed S2 V from 70 to 90 and 40 to 50								
	11:25 AM	92.30	54.80		65.06	70.84	69.34	70.91	74.07	70.09	66.37	70.93	67.43	70.05	63.14	70.14	66.25	71.48
	4:00 AM	97.30	44.80		66.31	70.65	69.76	70.82	74.78	70.46	68.04	70.84	68.34	70.48	64.16	71.04	63.81	71.88
					changed dampers from 100 to 30%													
	6:23 AM	96.50	48.10		63.31	70.47	67.87	70.84	72.14	70.28	63.57	70.73	61.68	70.11	59.18	70.75	63.91	71.65
					Shut off ERV 1 and closed dampers													
7/22/2019	6:17 AM	75.20	65.00		62.75	71.08	66.52	70.65	68.47	71.32	58.56	72.13	62.19	71.11	60.52	71.04	61.32	71.94
	11:35 AM	82.00	57.40		60.27	70.70	62.64	70.32	66.44	70.08	60.03	70.24	58.09	70.44	57.50	69.94	61.62	70.38
	7:50 PM	70.80	81.80		63.44	72.02	64.40	71.82	68.48	71.97	59.45	72.03	60.96	72.36	60.40	72.31	60.93	73.19
7/23/2019	5:27 AM	68.40	78.40		66.12	71.43	67.87	71.08	70.13	71.24	60.05	72.48	65.31	71.77	64.41	71.89	61.85	72.57
	9:00 AM				set up ventilation adjusted S4, 3, 16, 14, 2 dampers to 30% S1 to 50, S12 to 60													
	4:48 PM	75.10	65.00		62.95	70.71	65.54	70.83	67.91	70.50	60.27	71.15	61.73	71.15	59.61	70.72	61.93	71.12
					changed dampers to 0% shut off ERV													
7/24/2019	7:04 AM	69.10	76.00		66.09	70.46	68.91	70.26	67.27	70.23	60.09	70.56	62.45	70.62	62.47	70.63	61.94	70.70
7/26/2019	6:58 PM				Changed schedule to 24 hours													
7/28/2019	6:25 PM	87.80	55.80		61.16	70.30	62.78	70.89	66.08	70.15	61.96	70.05	57.73	70.10	56.85	70.83	61.21	70.36
					Changed dampers from 0 to 30													
7/29/2019	2:17 PM	91.70	49.00		64.02	70.01	66.31	70.22	68.98	70.30	63.43	70.25	60.94	70.13	60.48	70.76	65.68	70.61
7/30/2019	1:11 PM	93.70	51.10		65.52	70.75	66.91	70.19	69.15	70.35	63.75	70.65	62.04	70.71	61.57	70.28	66.68	70.53
	7:20 PM	86.10	57.50		62.26	71.01	64.76	70.77	68.57	70.58	63.11	70.70	59.18	70.73	58.55	70.57	65.06	70.25
8/3/2019	3:17 PM	86.10	52.80		62.32	70.63	65.10	70.10	67.81	70.68	62.32	70.91	60.51	70.69	60.07	70.33	65.25	70.34
8/4/2019	9:15 AM	84.10	53.90		64.46	70.91	66.26	70.77	68.48	70.88	62.48	70.72	64.83	70.67	62.09	70.65	67.55	70.30

					RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp
Date	**Time**	**OAT**	**OARH**		**S4**	**S4**	**S3**	**S3**	**S16**	**S16**	**S14**	**S14**	**S2**	**S2**	**S1**	**S1**	**S12**	**S12**
	3:45 AM	91.60	42.80		61.23	70.31	64.35	70.96	67.43	70.47	63.43	70.30	59.21	70.14	58.21	70.49	63.81	70.59
										S16 changed max V from 100 to 70								
8/5/2019	9:48 AM	77.60	48.20		59.68	70.41	61.59	70.59	63.57	70.87	61.16	70.88	59.02	70.94	58.99	70.94	59.88	70.86
8/7/2019	2:00 PM	86.70	55.50		68.15	70.37	68.47	70.60	69.19	70.60	66.03	70.97	62.90	70.64	62.76	70.03	67.24	70.10
8/13/2019	5:03 PM	76.40	72.40		68.06	70.68	66.95	70.83	67.93	70.77	63.21	70.50	63.88	70.43	63.94	70.81	66.87	70.38

Appendix B
Implementation Drawings

BUILDING AUTOMATION SYSTEM MODIFICATIONS (PHASE 1)

PREPARED FOR:

BEECHER ROAD SCHOOL
40 BEECHER ROAD, WOODBRIDGE, CT 06525

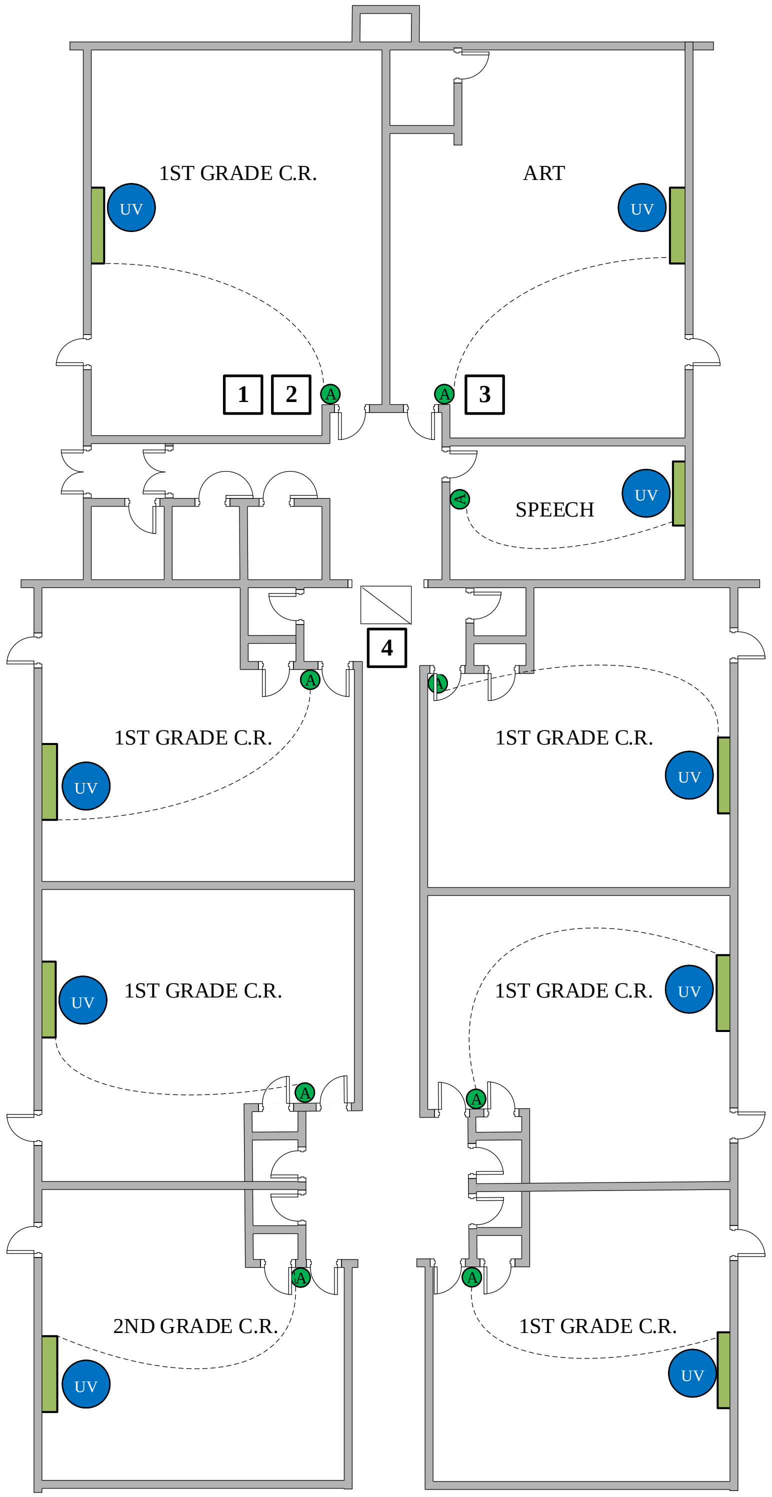
PREPARED BY:

VAN ZELM ENGINEERS
10 TALCOTT NOTCH ROAD
FARMINGTON, CT 06032

DRAWING LIST

100% CONSTRUCTION DOCUMENTS

MARCH 18, 2019



PARTIAL FLOOR PLAN A WING

LEGEND	
A	PROVIDE NEW WALL MOUNTED TEMPERATURE, HUMIDITY AND CO2 SENSOR
UV	APPROXIMATE LOCATION OF EXISTING UNIT VENTILATOR

DRAWING NOTES (NEW WORK) X

1. CONFIRM LOCATION OF THE EXISTING SENSOR AND INSTALL NEW SENSOR IN SAME LOCATION UNLESS OTHERWISE INDICATED (TYPICAL FOR ALL SENSORS).
2. SUBMIT CUT SHEETS OF SENSOR TO ENGINEER FOR REVIEW AND APPROVAL (TYPICAL FOR ALL SENSORS).
3. PROVIDE ALL WIRING FROM NEW SENSORS TO EXISTING UNIT VENTILATORS (TYPICAL FOR ALL SENSORS).
4. ER-1 LOCATED ON ROOF. CONFIRM IF FAN HAS A MOTORIZED OR GRAVITY DAMPER IN PLACE.

VANZELM ENGINEERS	PROJECT NAME: BEECHER ROAD SCHOOL 40 BEECHER ROAD, WOODBRIDGE, CT 06525	DESCRIPTION: BAS MODIFICATIONS-A WING (PHASE 1)	DATE MARCH 18, 2019	DWG NO. BAS-1
	VANZELM PROJECT NO. 2018137.01		SCALE: NONE	REV NO. 0

Unit Ventilators

Scope of Work

The intent of this portion of the project is to revise the control of the unit ventilators to provide improved dehumidification of the building. The major contributing causes of the excessive humidity are the excess capacity of the units and the amount of unconditioned fresh air. The following revisions are intended to minimize the effects of these issues.

The unit ventilators are draw through, with hot and chilled water and face and bypass dampers. The system is two pipe and the single coil and modulating two way control valve is common to both the hot and chilled water systems.

Changes included under this scope include:

The existing room temperature sensor will be replaced with a new combination sensor that will measure room temperature, room relative humidity percent and room carbon dioxide level in parts per million.

The addition of a CO2 sensor will allow the existing ASHRAE cycle 2 ventilation sequence to be modified to incorporate a demand controlled ventilation sequence. Additionally, the CO2 sensor will be used to allow the fan to be cycled on a call for cooling. If the room temperature is satisfied and the CO2 levels increase, the fan will be cycled back on to provide the required ventilation.

The relative humidity sensor will be used to monitor the room relative humidity and may also be used to start the unit based on an unoccupied high humidity limit.

Software provisions will be made to limit the amount the valve is allowed to open in the cooling mode.

The fan speed will be set to low during the initial cooling season evaluation.

The following sequence has been revised to incorporate the required changes.

Safeties
A water leak detector located in the unit drain pan shall indicate an alarm at the BMS whenever water is detected.

A unit provided freezestat is hardwired to shut the fan down.

Unoccupied Mode
The fan shall remain deenergized. The face and bypass dampers and coil valve shall remain closed.

If the space temperature falls below 60˚F (adj.), the unit shall operate as per warm up mode until the space temperature exceeds 64°F (adj.). The unit shall run a minimum of 1/2 hour (adj.) after start up.

If the space temperature rises above 80˚F (adj.), the unit shall operate as per cool down mode until the space temperature falls below 76˚F (adj.). The unit shall run a minimum of 1/2 hour after start up.

If the relative humidity rises above 65% (adj), the unit shall start and operate as per cool down mode until the relative humidity falls to 60%.

Warm Up
During the heating season, a warm up program shall be invoked if the space temperature is below 60˚F (adj.) upon unit start up. During the warm up mode, the unit ventilator shall operate on 100% return air. After warm up (space temperature above 66˚F (adj.)), the unit shall be controlled as described in occupied mode.

Cool Down
During the cooling season, a cool down program shall be invoked if the space temperature is above 80˚F (adj.) upon unit start up. During the cooldown mode, the unit ventilator shall operate on 100% return air. After cooldown (space temperature below 74˚F (adj.)), the unit Shall be controlled as described in occupied mode.

Heating Cooling Mode
The system shall be indexed to either heating or cooling mode globally by the BAS.
When the chilled water system is enabled, the unit ventilators will be indexed to the cooling mode. When the chilled water system in not active and unavailable, the unit ventilators will operate in heating mode. This may be performed automatically and or manually from the BAS graphic page. The active mode will be displayed on the unit ventilator graphic page.
The existing water temperature sensors on the supply pipe in the unit ventilators will be relocated to the return pipe between the control valve and the coil. This sensor will be used to monitor the status of the coil and control valve but not for control.

The existing room occupancy sensors will be used for monitoring only but not for control.

Heating Mode
Occupied Mode
The unit shall be started based upon a start time optimization program, time of day schedule or manual command. using space occupancy sensor.
The supply fan shall run continuously in heating mode.

If the outside air temperature is above 45˚F (adj.), the face and bypass dampers shall be positioned to allow full flow over the coil and the coil valve will modulate as necessary to maintain set point. If the outside air temperature is below 45˚ (adj.), the coil valve shall be fully open, and the face and bypass dampers shall modulate as necessary to maintain set point.

The discharge air temperature sensor shall act as a low limiting sensor in heating mode. When the discharge air temperature falls below the discharge air low limit (DALL) setpoint of 65˚F (adj.), the heating signal shall be increased to the valve or face and bypass damper, (whichever is being allowed to modulate), to modulate the valve open or the face and bypass damper toward the face position to maintain the discharge air temperature at the DALL setpoint. In cooling mode, the sensor will not limit the valve or face and bypass damper.

Cooling Mode
The fan shall cycle on a call for cooling in cooling mode.
The fan shall cycle on anytime the room CO2 level is above 1200 PPM. (adj)
The fan shall cycle off when the CO2 level falls below the setpoint minus a differential of 50 PPM (adj)

The face and bypass damper shall be opened to full face position.
The coil valve shall modulate as necessary to maintain the space temperature set point.
The valve shall have an adjustable stroke limit programmed to allow the valve to be manually limited from opening to 100% for capacity control. Each unit ventilator may need to have a unique limit setting.

Ventilation Mode
The minimum outside air damper position setpoint shall initially be set to 0% (adj.)
The unit will incorporate a demand controlled ventilation program.
If the room CO2 level rises above the setpoint of 1200 PPM (adj), the outside air damper shall begin to modulate open to bring in more ventilation air.

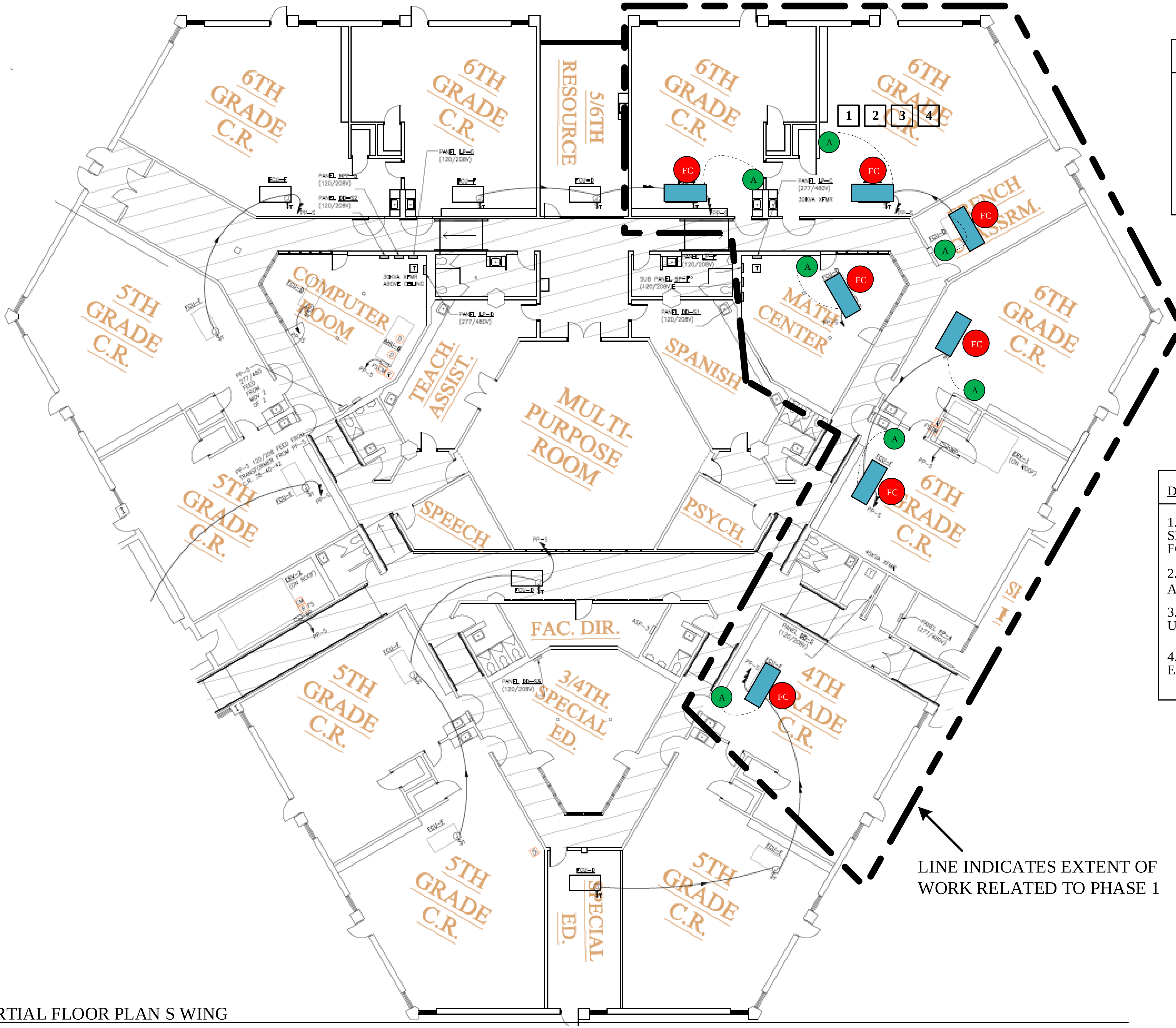
Economizer Mode
The economizer will be allowed to operate when the outside air temperature is below 55˚F (adj)

Building Exhaust
The intent is to try to relieve the building naturally without operating the exhaust fan if possible.
During the occupied mode, the exhaust fan damper will be opened and the fan will remain off.

It needs to be verified if the exhaust fans currently have barometric or motorized back draft dampers. During the commissioning of the new sequences, it will be determined if and when the fan may need to be started.

This would be based on the damper positions of the associated unit ventilators.
If the building is "over" pressurized the fan will need to be started by the BAS.

If it is determined during commissioning, that the building is able to relieve through the open damper with the exhaust fan off of if the fan must be staged on depending on the unit ventilator damper positions the damper will need to be automatically opened by the BAS and the fan started independently by the BAS. This will require two separate digital outputs.



PARTIAL FLOOR PLAN S WING

LEGEND

- (A) PROVIDE NEW WALL MOUNTED TEMPERATURE, HUMIDITY AND CO2 SENSOR
- (FC) APPROXIMATE LOCATION OF EXISTING FAN COIL UNIT

DRAWING NOTES (NEW WORK) [X]

1. CONFIRM LOCATION OF THE EXISTING SENSOR AND INSTALL NEW SENSOR IN SAME LOCATION UNLESS OTHERWISE INDICATED (TYPICAL FOR ALL SENSORS).
2. SUBMIT CUT SHEETS OF SENSOR TO ENGINEER FOR REVIEW AND APPROVAL (TYPICAL FOR ALL SENSORS).
3. PROVIDE ALL WIRING FROM NEW SENSORS TO EXISTING FAN COIL UNITS (TYPICAL FOR ALL SENSORS).
4. MOTORIZED OUTDOOR AIR AND SPILL DAMPERS ARE LOCATED IN EACH ROOM (NOT SHOWN FOR CLARITY).

VANZELM ENGINEERS	PROJECT NAME: BEECHER ROAD SCHOOL 40 BEECHER ROAD, WOODBRIDGE, CT 06525	DESCRIPTION: BAS MODIFICATIONS-S WING (PHASE 1)	DATE MARCH 18, 2019	DWG NO. BAS-3
	VANZELM PROJECT NO. 2018137.01		SCALE: NONE	REV NO. 0

Fan Coil Units

Scope of Work

The intent of this portion of the project is to revise the control of the fan coil units to provide improved dehumidification of the building. The major contributing causes of the excessive humidity are the excess capacity of the units and the amount of unconditioned fresh air. The following revisions are intended to minimize the effects of these issues.

The fan coil units are ducted to Energy Recovery Units used to provide ventilation air. The system is two pipe and the single coil and modulating two way control valve is common to both the hot and chilled water systems.

Changes included under this scope include:

The existing room temperature sensor will be replaced with a new combination sensor that will measure room temperature, room relative humidity percent and room carbon dioxide level in parts per million.

The addition of a CO2 sensor will be used to allow the fan to be cycled on a call for cooling. If the room temperature is satisfied and the CO2 levels increase, the fan will be cycled back on to provide the required ventilation.

The relative humidity sensor will be used to monitor the room relative humidity and may also be used to start the unit based on an unoccupied high humidity limit.

Software provisions will be made to limit the amount the valve is allowed to open in the cooling mode.

Sequence of Operation

Each fan coil unit will be controlled in two distinct mode of operation:
Occupied & Unoccupied. These modes will be determined by schedules set in the building manager and as provided by the building management.

Heating Cooling Mode
The system shall be indexed to either heating or cooling mode globally by the BAS.
When the chilled water system is enabled, the fan coil units will be indexed to the cooling mode. When the chilled water system in not active and unavailable, the fan coil units will operate in heating mode. This may be performed automatically and or manually from the BAS graphic page. The active mode will be displayed on the fan coil unit graphic page.

The existing water temperature sensors on the supply pipe at the fan coil units will be relocated to the return pipe between the control valve and the coil. This sensor will be used to monitor the status of the coil and control valve but not for control.

The existing room occupancy sensors will be used for monitoring only but not for control.

Occupied Mode
The fan coil unit shall be started by the BMS based upon a start time optimization program, time of day schedule or manual command and shall run continuously.

Upon a command to start the FCU, the FCU’s outside air/spill air damper from the energy recover units shall open to the minimum OA damper position per local code.

The coil control valve shall modulate as necessary to maintain the space temperature set point.

Heating Mode
The supply fan shall run continuously in heating mode.
In heating mode, the coil control valve shall modulate open upon a fall in space temperature below set point and shall modulate closed upon a rise in space temperature above set point.

Cooling Mode
The fan shall cycle on a call for cooling in cooling mode.
The fan shall cycle on anytime the room CO2 level is above 1200 PPM. (adj)
The fan shall cycle off when the CO2 level falls below the setpoint minus a differential of 50 PPM (adj)

In cooling mode, the coil control valve shall modulate open upon a rise in space temperature above set point and shall modulate closed upon a fall in space temperature below set point.

The valve shall have an adjustable stroke limit programmed to allow the valve to be manually limited from opening to 100% for capacity control. Each unit ventilator may need to have a unique limit setting.

Unoccupied Mode
The fan coil unit shall deenergize and the coil valve shall close. The outside air damper shall remain closed.

If the space temperature rises above 80°F (adj.), the unit shall operate as per enabled mode until the space temperature falls below 76‘F (adj.). The unit shall run a minimum of 1/2 hour after start up.

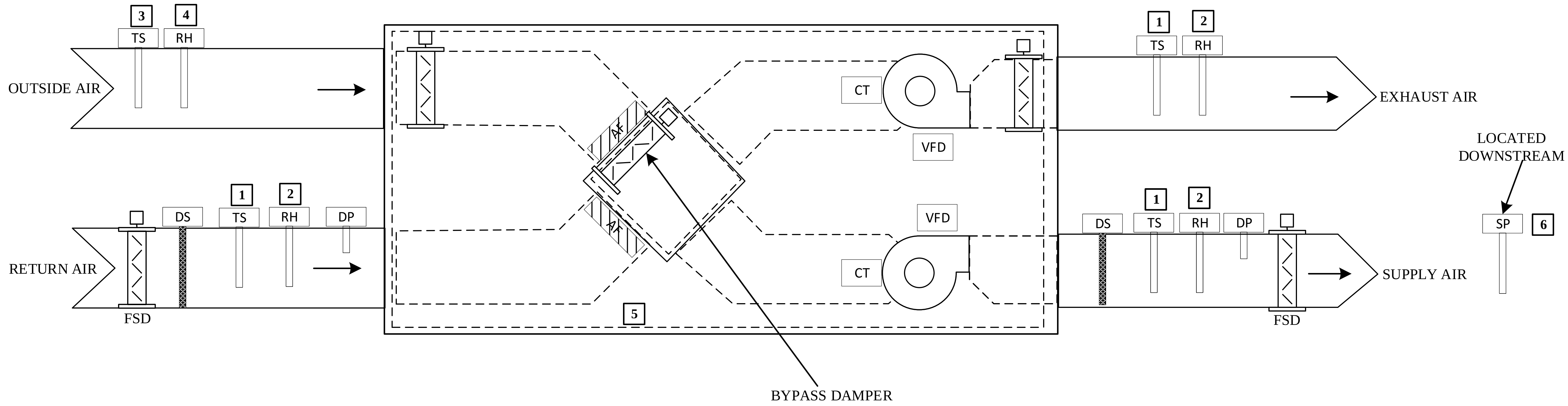
If the space temperature falls below 60‘F (adj.), the fan coil unit shall operate as per occupied mode until the space temperature exceeds 64°F (adj.). The unit shall run a minimum of 1/2 hours (adj.) after start up.

The fan coil DDC controller shall be programmed for occupancy override. When occupancy override is activated via a pushbutton on the space temperature sensor or via a BMS command, the fan coil shall control as per enabled mode and as per the occupied cooling set point. The fan coil shall operate in occupancy override mode for a period of 2 hours (adj.).

If the relative humidity rises above 65% (adj), the unit shall start and operate as per cool down mode until the relative humidity falls to 60%.

Safeties

A water leak detector located in the unit drain pan shall indicate an alarm at the BMS, close the dual temp control valve and disable unit whenever water is detected.



ENERGY RECOVERY VENTILATORS (TYPICAL OF 4 UNITS)

DRAWING NOTES (NEW WORK) X

1. PROVIDE AND INSTALL NEW TEMPERATURE SENSOR.
2. PROVIDE AND INSTALL NEW RELATIVE HUMIDITY SENSOR.
3. PROVIDE GLOBAL OUTSIDE AIR TEMPERATURE.
4. PROVIDE GLOBAL OUTSIDE AIR RELATIVE HUMIDITY.
5. REMOVE EXISTING JCI FROST CONTROL, ECONOMIZER CONTROL, AND SUMMER RECOVERY MODULATING DAMPER CONTROL LOCATED INSIDE OF UNIT.
6. CONFIRM AND RECORD EXACT LOCATION OF EXISTING DUCT STATIC PRESSURE.

VANZELM ENGINEERS	PROJECT NAME: BEECHER ROAD SCHOOL 40 BEECHER ROAD, WOODBRIDGE, CT 06525	DESCRIPTION: ERV MODIFICATIONS (PHASE 1)	DATE MARCH 18, 2019	DWG NO. BAS-5
Beecher Road School	VANZELM PROJECT NO. 2018137.01		SCALE: NONE	REV NO. 0

Energy Recovery Ventilators

Scope of Work

The intent of this portion of the project is to place the four ERV units under complete Honeywell BAS control.

Work required to accomplish this includes removing the three Johnson Controls 350 controllers in each unit and providing the existing and new additional Honeywell control points which include:

AI	Global Outside Air Temperature Sensor
AI	Global Outside Relative Humidity Sensor
UI 1	Existing Discharge Duct Static Pressure Sensor
UI 2	Existing High Discharge Static Pressure Switch
UI 3	Existing Low Return Static Pressure Switch
UI 4	New Supply Air Temperature Sensor
UI 5	New Supply Air Relative Humidity Sensor
UI 6	New Return Air Temperature Sensor
UI 1 (New Controller)	New Return Air Relative Humidity Sensor
UI 2 (New Controller)	New Exhaust Air Temperature Sensor
UI 3 (New Controller)	New Exhaust Air Relative Humidity Sensor
DO 1	Existing Unit Enable Relay
DO 2	Existing Exhaust Air Damper Relay
DO 3	Existing Outside Air Damper Relay
AO 1	Existing Supply Fan Speed VFD
AO 2	Existing Return Fan Speed VFD
AO 3(New AO)	Existing Face & Bypass Damper Actuator

ERV Sequence of Operation

The ERVs are ducted to, and provide ventilation air to, the fan coil units. Each fan coil unit has associated fresh air and exhaust air dampers. When an FCU runs, the associated dampers open to allow the ventilation and exhaust air to the FCU. When the FCU is off, the dampers are closed.

The revised FCU sequence will cycle the FCU fan on a call for cooling. This will result in the ERV static pressure to increase. Provisions should be made to reset the ERU static pressure setpoint based on the number of fan coil units that are running.

The following existing sequence has been revised to include the new modified control of the face and bypass damper formerly controlled by the unit manufacturer installed controls.

Safeties

The existing supply and/or return smoke detector shall stop the supply and return/exhaust fans upon the presence of smoke through the FAS.

An existing high discharge air pressure switch located downstream of the supply fan and upstream of the closest damper shall stop the supply and return/exhaust fans when duct pressure exceeds design.

An existing low suction air pressure switch located upstream of the return/exhaust fan and downstream of the closest damper shall stop the supply and return/exhaust fans when duct pressure decreases below design.

Occupied Mode

Upon a command to start from the BAS, all associated two position dampers (i.e. supply/return fire/smoke dampers, supply fan isolation dampers) shall open and be proven by an end switch. Once the dampers have been proven open, the ERV supply and exhaust fans shall start at minimum speed.

OA Damper (Outside Air Damper End Switch)

When the unit is power on by the BAS, the unit Outside Air Damper (DO) is powered open. The power for the Supply Blower VFD runs through the damper end switch DOS2, so when DO is approximately 3/4 open, DOS2 closes and allows the Supply Blower VFD to operate. When the unit is powered off, DO will power closed. The Supply Blower can be controlled remotely by removing red jumpers and providing remote contactors between terminals #1B, #2, or #3 (as indicated).

EA Damper (Exhaust Air Damper End Switch)

When the unit is power on by the BAS, the unit Exhaust Air Damper (DE) is powered open. The power for the Exhaust Blower VFD runs through the damper end switch DES2, so when DE is approximately 3/4 open, DES2 closes and allows the Exhaust Blower VFD to operate. When the unit is powered off, DE will power closed. The Exhaust Blower can be controlled remotely by removing red jumpers and providing remote contactors between terminals #1B, #2, or #3 (as indicated).

SA Motor VFD (Control Signal by BAS)

The unit is provided with a VFD on the Supply Air Motor. The control signal to the VFD is by the BAS.

EA Motor VFD (Control Signal by BAS)

The unit is provided with a VFD on the Exhaust Air Motor. The control signal to the VFD is by the BAS.

Fan Speed Control

The supply fan VFD’s shall control to maintain the duct static pressure set point as sensed at a point 2/ 3 downstream of the supply fan.

The BAS shall poll the associated fan coil units and reset the static pressure setpoint downward as the number of operating fan coil units is reduced. As the number of operating units increases, the static pressure setpoint shall be increased. The actual setpoint range will be determined during the commissioning of the revised sequence.

The supply and exhaust fan VFD shall operate with matching speeds with an offset (adj.). The offset will be determined during air balancing. The supply and exhaust fan speed shall allow for balanced air flow across the heat exchanger to maximize the heat exchange of the two airflow paths.

At any time, a fan command does not equal a fan status, except immediately after startup, a fan failure alarm shall be generated on the BMS that notifies the BMS operator of the specific fan that has failed.

Face and Bypass Damper

The damper will be controlled by the BAS as follows:

Frost Control (Face & Bypass Air Damper) (Modulating)

As the temperature of the exhaust airstream leaving the exchanger falls below the adjustable Frost Control setpoint temperature of 25°F, the BAS shall modulate the Face & Bypass Damper (DFB) to the bypass position as required to maintain the frost control setpoint. By keeping the exhaust airstream above 25°F (adjustable), frost is prevented from forming in the exchanger. As the temperature of the exhaust airstream rises above the T-F setpoint, DFB will modulate to the face position.
(Alternate) use dewpoint instead of dry bulb to try to extend the heat recovery range below 25˚F.

Economizer Control (Face & Bypass Air Damper) (Modulating)

As the temperature of the supply airstream leaving the exchanger rises above the Economizer setpoint (60°F, adjustable) the BAS shall modulate the Face & Bypass Damper (DFB) to the bypass position as required to maintain the setpoint. As the temperature of the discharge temperature drops below the economizer discharge setpoint, the BAS shall modulate DFB to the full-face position.

Summer Recovery Changeover (Face & Bypass Damper)

When the temperature of the outside air rises above the Summer Changeover setpoint (75°F), the BAS shall switch the unit from the economizer bypass mode to maximum heat recovery. The Outside Air Face & Bypass Damper (DFB) shall modulate to the full-face position for full heat recovery.

Unoccupied Mode:

In the unoccupied mode, the ERV supply and exhaust fans shall stop, the VFDs shall ramp down to off, and the outdoor air dampers shall close. After a 30 second time delay, the return air and discharge air smoke dampers shall close, and the duct mounted combination fire/smoke dampers shall close.