FUSS & O'NEILL

January 15, 2020

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Barnard Magnet School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Barnard Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations and remote building automation system (BAS) on October 15, 2020, it is our opinion that the building's ventilation systems have some deficiencies we that will need to be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Four air handling units (AHU), four heat-recovery air handling units (HR-AHU) and thirty-five fan coil units (FCU) serve the building with hydronic hot and chilled water loops for heating and cooling. These units were installed during a major renovation in 2008. The four HR-AHUs supply outdoor air to the classrooms and the outdoor air (OA) connections on the FCUs. Our field work determined that the FCU's for each classroom are activated via occupancy sensor. Twenty-seven shutoff reheat VAV boxes serve various spaces on the ground and main floors, and are primarily associated with AHU-3. The Nature Center is served by a FCU with heat pump coil, and has demand-controlled ventilation.

Upon inspection, the units appeared in good condition. Some damper positions do not appear correct as the total of OA and RA damper % open is greater than 100%. This should be evaluated for control accuracy. Unit damper positions recorded were as follows:

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Unit	OA Damper	RA Damper	Filter Status
AHU-1	75% open	60% open	Replace
AHU-2	Not observable due to location		
AHU-3	100% open	Closed	Replace
AHU-4	Not observable due to location		
HR-AHU-1	100% open	Closed	Replace
HR-AHU-2	50% open	100% open	Replace
HR-AHU-3	20% open	Not available	Replace
HR-AHU-4	20% open	Not available	Ok

The linkage on HR-AHU-4 appeared to be malfunctioning, as only a portion of the OA blades were open. The energy wheel on HR-AHU-1 was off. Of the 26 exhaust fans (EF), 10 were in operation at the time of the visit.

Classrooms are served by supply and return ductwork, hydronic baseboard radiation along exterior walls, and operable windows. The office adjacent to the Custodian's Office is a former supply closet and has no ventilation supply or return. Bathrooms were musty due to inactive EFs. Returns in the corridor and Cafetorium were dirty and should be cleaned.

Building Automation System Review Findings

It was noted that the BAS associated with this school is well featured and easy to use. One minor issue is temperature readings that deviate from the set point are not highlighted to attract attention, forcing manual review of each room for the BAS operator. The ventilation system includes CO_2 feedback control, providing the ability to increase the ventilation levels as needed via CO_2 set points.

During our review, the global CO_2 sensor read an unrealistically low level, indicating need for sensor replacement. Further review on January 15 indicated that HR-AHU-4 OA (damper 10) and exhaust air (EA) dampers were closed, and RA dampers 100% open. OA damper minimum position should be set to 30% open during pandemic condition, using freeze protection protocols to reduce as required, but not fully closed.

EF-7, 9, and 12 were enabled, but not running. Toilet room exhaust fan EF-8 was enabled but not running. EF-9 was in alarm. The CO_2 sensor in room 303 is missing a cover, and a temperature sensor is missing in room 304.

Nurse's Suite:

The school nurse's office is located within a health suite that includes a reception area, two offices, an isolation room, an exam room, storage room, medical room, and a dedicated bathroom. The

isolation room (Room 192) is equipped with supply air, and operable windows. The health suite is conditioned and ventilated by AHU-3, which also serves the rest of the Health Suite as well as the administration areas across multiple floors.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace filters in all AHUs and HR-AHUs. Upgrade RA filters and final filters to MERV 13 or better.

2. Install a portable HEPA filtration machine capable of 6 air changes per hour (ACH) to clean the air in the isolation room during and after occupation. Close off supply air diffuser to create a passive isolation room appropriate for short-term occupation. The isolation room should not be positively pressurized. If possible, install an exhaust fan through a window or outside wall to negatively pressurize the space. This will prevent cross-contamination with adjacent spaces.

   If a return can be installed, incorporate a HEPA-filtered negative air machine connected to the new return grille. Reduce supply air to both rooms to ensure a negatively pressured environment. Install a HEPA-filtered negative air machine to the isolation rooms' return grilles. Reduce supply air to ensure a negatively pressured environment.

3. For pandemic operation, overwrite the occupancy sensor activation of FCU's and VAV box settings during the occupied cycle. The ventilation should run all day regardless of room occupancy.

4. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.

6. Evaluate damper positions to ensure controllability. Total should be equal to 100% airflow.

7. Address exhaust fan inconsistencies.

8. Schedule EFs serving occupied areas to run continuously during occupied hours. Field-verify that all general EFs run when enabled by the BAS.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace CO_2 sensor cover in Room 303.
2. Clean Cafetorium return grilles.
3. Add individual CO_2 sensors to higher-populated rooms, such as conference rooms, not currently equipped with such sensors, to add assurance that these areas are receiving adequate ventilation.
4. Install ventilation supply and return ductwork in the office adjacent to the custodian's office.

As part of a future renovation, it is recommended to incorporate the following:

1. Add exhaust system graphics to the BAS main menu welcome page so they are more accessible. Set up trend logs of BAS point values.
2. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
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- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
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via email: phillip.penn@nhboe.net

RE: L.W. Beecher Magnet School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the L.W. Beecher Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 13, 2020 and remote building automation system (BAS) review on October 11, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and code violations that will need to be corrected and re-evaluated before considering reoccupying the building. A summary of our findings and recommendations are shown below.

Field Observations

Thirteen packaged rooftop units (RTUs), including one makeup air unit (MAU) serve the building. These units provide all of the building's outdoor air and are equipped with chilled water cooling and hot water heating. Within the building, the variable air volume (VAV) boxes with hot water reheat coils control the airflow into each room from the RTUs. 18 exhaust fans (EF) ventilate toilet rooms, storage rooms, RTU-7&8, and lab hoods. This equipment was installed as part of the HVAC renovation in 2005. In general, HVAC systems are not functioning correctly.

At the time of our site visit, observable air filters in RTUs were noted to be in good condition. Many filters were not observable as internal equipment access was not provided. RTU-6, serving the Computer Room (Room 251), was reported as not operational, but DDC review showed it in operation. At the time of our inspection, most filters were reported to have been upgraded to MERV 13 filters by custodial personnel. Most of the outdoor air (OA) dampers were witnessed as open, with the exception of RTU-6, RTU-8, RTU-9, and RTU-11. RTU-10 outdoor air damper was minimally open. RTU-7, which serves the art room, was not running. Of the 18 exhaust fans, only one toilet room fan, EF-10, was in operation.

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Building Automation System Review Findings

Global control points such as the outdoor air temperature and outdoor air CO_2 sensor cannot be located on the BAS. CO_2 sensors are located on the design drawings within the return ducts, however, and may simply not be incorporated into unit operation. At the time of review, none of the units were in economizer mode and chilled and hot water valves in open position. According to the BAS, RTU-1 outdoor air damper was 100% open, return air damper was also 100% open and exhaust air damper was 67% open. So many simultaneously open dampers is an indication that one or more dampers or damper sensors are malfunctioning. Similar issues exist for RTU-3 and RTU-6. In addition to damper malfunctions, the return fan for RTU-6 was enabled but off, outdoor air damper was at 100% but the mixed air temperature was at 70F while the outdoor air temperature was significantly lower. This is an indication that the mixed air temperature sensor may also be malfunctioning. RTU-6, 7, 8, and 10 have fans that were not running, indicating other control issues.

Multiple pieces of equipment were reported as malfunctioning. The split AC unit in the Hub Room was reported as in need of refrigerant. The makeup air unit feeding the kitchen was reported to not run in tandem with the kitchen exhaust hood EF-9. Upon examination of the MAU, the filters were in good condition, the outdoor air damper was closed, and cobwebs within the outdoor air intake indicated lack of use. Finally, Room 304 was reported to have a leak in the cooling season, suggesting condensation may be leaking onto the ceiling tiles.

Heating hot water is circulated throughout the building by supply pumps P-4 and P-5. The VFD associated with P-4 was reported to be malfunctioning; if the amperage exceeds 50 Hz, the pump will trip and restart. Pump P-5 is not set to start during a trip event. Pump P-5 should be set as lead pump until this issue is resolved. A heating hot water leak was found above boiler HWB-B, causing corrosion on the boiler casing. A broken pressure gauge was found on the radiant heating hot water circulating pump serving the radiant floor and baseboard.

The Chiller is traditionally turned off on October 15. However, it was reported that power interruptions appear to reset the Chiller, which then restarts and responds to temperature rather than calendar lockout settings.

Nurse's Suite:

The 2nd floor Nurse's Suite (surrounding Room 234) consists of Nurse Reception (Room 234D) with Cot Area (Room 234), a Lab (Room 234C), an Exam Room (Room 234B), an Office (Room 234A), and one dedicated bathroom with exhaust (Room 234E). Office 234A has been identified as an isolation room with the Lab (Room 234C) as a backup. This arrangement adheres to state and local requirements for an isolation room. Room 234A is located on an outside wall, has supply and return grilles, and is served by RTU-2. This RTU also serves the adjacent 3rd grade Classroom 235, adjacent corridor and Guidance Suite.

Storage Room 250A does not have exhaust and was noted as musty. The Hub Room did not have return grilles. Return louvers in the Foyer were noted as dirty. The gymnasium returns face towards the ceiling, which makes identification of clogged returns difficult.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period.
2. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
3. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
4. Set exhaust fans serving occupied areas to run continuously during occupied hours.
5. Install a HEPA-filtered negative air machine to the isolation rooms' return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply and return grilles to create a passive isolation room appropriate for short-duration occupancy. An exhaust fan through a window or outside wall is recommended in this case and will negatively pressurize the space to prevent cross-contamination with adjacent spaces.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied.

1. Perform a complete controls re-commissioning for the RTUs. At a minimum, ensure dampers are functioning per sequence of operation, review outdoor air enable cooling set points (around 55F) and mixed air set points (45F if VAV reheat is available and 55F if no additional conditioning downstream). Determine if CO_2 sensors were installed in return ductwork as shown on the construction drawings. If so, incorporate into the DDC.
2. Set heating hot water pump P-5 as lead pump to maintain consistent heat throughout the building. Repair P-4 pump VFD.

3. Repair MAU and/or controls so it operates when Kitchen Exhaust Fan EF-9 operates.
4. Install return grille or exhaust in Hub Room. Connect to closes RTU ductwork.
5. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
6. Repair/replace split AC unit in Hub Room.
7. Investigate Chiller controls issue.
8. Install return or exhaust in Storage Room 250A.
9. Consider adding BAS exhaust fan graphic sets that show command, status and alarm. The exhaust fans are an important part of the overall building ventilation.

As part of a future renovation, it is recommended to incorporate the following:

1. Replace aging RTUs.
2. Rotate gymnasium return grilles to face downward for visible condition assessment.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta

David Turner

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Benjamin Jepson Magnet School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Benjamin Jepson Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 22, 2020 and remote building automation system (BAS) review on October 27, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Four indoor air handling units (AHU), one heat recovery unit (HRU), and twenty-eight exhaust fans (EF) serve the building, installed in 2006. These air handling units provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. All filters were replaced in June 2020, and are in good condition. The filters in AHU-1, however, were installed backwards. AHU-1 has 2" pre-filters and 4" final filters installed. The other AHUs and HRUs have 2" MERV 8 filters. The final filters for all units have been scheduled to be replaced with MERV 13 filters. The OA damper on AHU-2 appeared to be closed. All other units were noted to have open OA dampers. All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU.

Building Automation System Review Findings

Based on the remote review of the BAS, the system requires repair prior to opening the building. The building's CO2 sensors appear to have inconsistent/incorrect readings. Approximately 30% of the sensors show exactly the same value (750.0 ppm), which is very unlikely. Others read close to zero, indicating failure, some are "disabled" and the remaining 30% show reasonable values but should be confirmed due to errors elsewhere. In order to continue confidently using demand-

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controlled ventilation (DCV), the sensors must be re-calibrated or replaced. A review of ventilation effectiveness is built into this system via the quantity and placement of CO_2 sensors, but the current sensor condition rules out using it. Most VAV boxes use these CO_2 sensors to control their outdoor air (OA) intake.

In addition to the CO_2 sensors, the main HRU, which ventilate the office and classrooms show both the OA and exhaust air (EA) dampers as closed. The flow sensors within HRU-1 also appear to be inaccurate, as exhaust flow rate is shown to be much higher than supply flow rate. The system also shows HRU-1 to have closed outdoor and exhaust air dampers, even when the unit is supplying 7500 cfm of OA.

The BAS also has active alarms that must be investigated and corrected prior to re-opening. Some rooms in the BAS indicate an alarm condition, but the VAV graphic associated with that room does not indicate what that alarm is. There is also a gas meter pressure alarm that reads 0.00 in w.g., which indicates a faulty sensor as the gas-fired boilers appear to be working normally. The exhaust fans are not reported in the BAS, so their scheduled operation is not currently known. EF-12 and 17 were noted to be running during the site visit. All other exhaust fans were not accessible due to ongoing roofing work.

Nurse's Suite:

The school nurse's area is only one office. At the time of our visit, hard-walled cubicles were being built to serve as isolation rooms within the computer lab. These cubicles have screen doors and partitions that do not extend to the ceiling, making them unacceptable as isolation rooms. The computer lab as a whole is acceptable to be considered a single isolation room, but individual cubicles will allow airflow and aerosols between compartments, and is not appropriate for both COVID and non-COVID patients.

The computer lab being considered as an isolation room has supply and return connections to AHU-1. Filtering all returns to AHU-1 is recommended to mitigate viral particles from reentering the supply airstream, as is the reduction of supply air and addition of an exhaust fan to depressurize the room. Confirm with the Department of Health that this approach is acceptable. If it is not, a new plan for an isolation room that conforms to the State's guidelines must be made and executed prior to re-opening the building.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Upgrade final filters in AHU-1 and 2" filters in all other AHUs to MERV 13.
2. Re-calibrate all CO_2 sensors to allow for confident use of demand-controlled ventilation.

3. Confirm with the Department of Health that the room arrangement selected as the isolation room is acceptable. Once the isolation room is confirmed, install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. A portable HEPA filter is recommended to clean the air within the room during and after occupation.
4. Investigate physical damper position in relation to BAS reporting and control, fan status, and airflow sensors to diagnose malfunction within all air handling units.
5. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
6. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
7. Set all exhaust fans serving occupied areas to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Add exhaust fan status and control points to the BAS.
2. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.

As part of a future renovation, it is recommended to incorporate the following:

1. Conduct a ventilation analysis of each VAV system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
2. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is*

no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Betsy Ross School - HVAC Mechanical Assessment – Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Betsy Ross School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 1, 2020 and remote building automation system (BAS) review on October 6, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

At the time of writing this report, no mechanical drawings of the building have been made available to us.

Field Observations

Seven indoor air handling units (AHU), and a make-up air unit (MAU) serve the building, installed in 2003. These units provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. Only AHU-2, 5, 6, and 7 were accessible during the site visit. At the time of our visit, all AHUs were equipped with MERV 8 filters dated August, 2016. The filters are well past their lifespan and should be replaced. AHU's serving multiple zones utilize variable air volume (VAV) boxes fine tune air delivery temperature with hot water reheat coils.

Most occupied rooms are equipped with both supply and return diffusers/grilles to provide ventilation air to/from an AHU. Dressing Rooms 201, 202, 207, and 208, as well as rooms 210, 230, and 242, do not have return or exhaust grilles. Art Storage Rooms 203 and 209, as well as Reflection Room 127, are being used as offices rather than storage rooms. These rooms do not have supply or exhaust grilles, which is not suitable for use as an office. Possible short cycling,

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caused by supply and return grilles closer than 10 feet, were noted in rooms 103, 105 and 106, 135, 138, 141, and 254. Short cycling can lead to inadequate mixing of supply air into the space.

Building Automation System Review Findings

The BAS system is well featured and easy to use. Trends can be created but are currently not populated. CO_2 sensors are located in upstairs classrooms and in AHU return air (RA) ductwork. Demand-controlled ventilation is possible and should be implemented in the system. CO_2 concentration level reporting should be added for each return air CO_2 sensor to indicate ventilation effectiveness. We recommend setting CO_2 set points at 600 ppm in order to ensure outdoor air (OA) is being supplied to the building. Faulty sensors throughout the system should be investigated, repaired or replaced. For example, some AHU RA sensors are reporting abnormally low CO_2 concentrations of 300 ppm, which indicates drift due to age. These sensors should be replaced. The BAS system also appears to have a purge mode, which typically brings in more outdoor air, but the BAS graphic does not indicate what this mode enables or controls.

Due to the large number of VAV boxes, not every sensor point could be verified for accuracy and function. A representative sample of VAV points was evaluated. Of those evaluated, some of the VAV flow meters are reporting flow rates different than their listed set points. These discrepancies should be investigated to identify if there is an issue within the BAS or at the VAV box itself, as incorrect flow rates will affect the amount of outdoor air flowing into the space. In some cases, tabular data available for these points disagreed with the same information reported on the VAV box graphic. Reports of cold areas in the building by occupants indicate a miscommunication between set points and VAV box operation.

Nurse's Suite:

The school nurse's area includes a reception area, an office, two exam rooms, and a dedicated bathroom. No isolation room was indicated during the site visit. An isolation room is required per State mandate. Once an isolation room is identified, a HEPA-filtered negative air machine should be installed in the return ductwork. The room's supply air should also be restricted to create a negative pressure in the space.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace filters in all AHUs. If possible, upgrade filters to MERV 13.
2. Identify an isolation room and install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

3. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
4. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
5. Investigate and repair/replace faulty sensors within VAV boxes and return air ductwork. All VAV box controllers and corresponding measurement points should to be checked to identify any boxes with incorrect flow rates relative to their set points.
6. Set all exhaust fans serving occupied areas to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean supply diffusers in Rooms 201, 202, 207 and 208. Consistent filter changes will prevent diffusers from becoming fouled.
2. Install supply and return ductwork to ventilate offices in Rooms 127, 203, and 209.
3. Install return grilles in rooms 127, 201, 202, 203, 207, 208, 209, 210, 230, and 242. Tie into nearest existing air handler return ductwork serving the corresponding areas.

As part of a future renovation, it is recommended to incorporate the following:

4. CO_2 reporting should be added in BAS for each return air CO_2 sensor as an indication of ventilation effectiveness.
5. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
6. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
7. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.
8. During future renovation, increase the distance between supply diffusers and return grilles in rooms with short cycling listed above.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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References:

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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Bishop Woods School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Bishop Woods School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 28, 2020 and remote building automation system (BAS) review on October 11, 2020, it is our opinion that the building's ventilation systems have some deficiencies. We recommend addressing them before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Eight packaged air handling units (AHU) and nine exhaust fans (EF) serve the building. These units supply all of the mechanical ventilation for the school, and were installed as part of the original HVAC system when the building was built in 2009. The AHU filters had been replaced in August 2020 and some units had MERV 13 filters installed. Air flow to individual zone is handled by VAV boxes. The VAV box filters were not observed due to their inaccessible location above the ceiling. All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from respective AHU with the exception of the Coach's Offices near the gym. These rooms contain supply diffusers only.

Building Automation System Review Findings

Based on our review of the BAS, the majority of AHUs and VAVs are in operational condition. AHU-4A serving the gym was off. Since the occupancy schedule is not available, it is not clear if the unit is enabled. The AHU outdoor air dampers are set between 50% and 100% open. Demand control ventilation is possible through return air CO_2 sensor in each unit. Return air CO_2 sensor readings are reasonable and are below the set point of 700 ppm. Individual zones/rooms are served by VAVs, utility rooms ae served by air conditioning units, and some areas served by unit heaters.

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Global points such as the outdoor air temperature and outdoor air enthalpy sensor are functional. Temperature readings of the entire building with the exception of 114 corridor are within the acceptable range.

With the exception of EF-3, RMF-2, and EF-7, the exhaust fans are operational. It was also reported that the makeup air unit (MUA-1) does not operate in tandem with kitchen exhaust fan.

The chilled water system is off and should be reviewed at the start of the cooling season. The hot water system is off at the time of the review.

Nurse's Suite:

The Nurse's Suite includes a laydown area with three beds, an Exam Room, a Storage Room, and a dedicated toilet room. Both the Exam Room and Storage Room have been identified as isolation rooms, and are each equipped with supply and return grilles. The storage room is also served by a plenum return grille, which is exhausted to the roof via EF-3. The suite is conditioned and ventilated by AHU-3, which recirculates air throughout the suite as well as the first floor Administration area, the Library, and some third floor classrooms.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. The Isolation room (formerly Storage Room) VAV return grilles should be closed/blocked to prevent room air from returning to AHU-3. The plenum exhaust should remain open to exhaust the space. Install a HEPA-filtered negative air machine to the room exhaust duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment.
2. Some units contain 2" pre-filters and 4" final filters. In these units, the 4" final-filters should be replaced with 4" MERV 13 final filters. The 2" pre-filters may remain MERV 8.
3. Units that contain only 2" filters should be replaced with 2" high-capacity MERV 13 filters.
4. VAV filters should be replaced with the highest rated filters recommended by the manufacturer.
5. Investigate why AHU-4A is off, the unit should operate during occupied and purge modes.
6. Investigate why EF-3, EF-7, and RMF-2 are turned off. Set all exhaust fans serving occupied areas to run constantly while the building is occupied.
7. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic

control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

8. CO_2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Investigate why the kitchen MUA unit does not function in tandem with the kitchen exhaust fan.
2. Maximize outdoor air dampers and economizer operation of AHUs during shoulder seasons and incorporate purge mode.
3. Install return air grille in Coach's office areas.

As part of a future renovation, it is recommended to incorporate the following:

1. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, independent HVAC systems with Normal and Isolation modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:

Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Hill Regional Career High School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at Hill Regional Career High School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 29, 2020 and remote building automation system (BAS) review on October 8, 2020, it is our opinion that the building's ventilation systems have significant deficiencies that should be addressed before the building is reoccupied. We recommend addressing them before reoccupying the building. A summary of our findings and recommendations are shown below.

Field Observations

Six indoor air handling units (AHU), eleven packaged rooftop units (RTU), eight unit ventilators (UV), and thirty-three exhaust fans (EF) serve the building, installed in 1996. These units are at the end of their useful life (typically 20 years) and should be replaced in the near future. These air handing units provide all of the mechanical ventilation for the school and are equipped with hot water coils and direct expansion (DX cooling coils. During the site visit, none of the AHUs were accessible due to their locations. Filters within RTU-2, 10, and 11 were also inaccessible, as tools were required to open the filter doors. The RTU filters that were observed were noted to be clean and undamaged MERV 8 filters. It is not clear when they were last replaced.

Although none of the units' outdoor air (OA) dampers were observed in the field, the BAS reports OA damper positions in all units as at least partially open. RTU-9, which serves the southwest 2nd and 3rd floor classrooms, was not running during the site visit. RTU-11 was running and would not shut off via disconnect.

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Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to and from an AHU or RTU. The kitchen staff offices do not have return or exhaust grilles. The janitor's office has exhaust grilles, but no supply diffusers.

Building Automation System Review Findings

Based on the review of the building's BAS, the system is in need of an overhaul in order to re-open the building with confidence that the HVAC systems will run as designed. It is recommended that alarms for all comfort and IAQ variables be added to the BAS and an alarm summary graphic is added to make it possible to identify issues within the system as they arise. The school should also be added to the Tritium web server so that alarms are captured when they activated.

AHU and RTU OA damper positions are reported in the BAS, however, in some cases the reported OA damper position is less than the minimum damper setting (such as AHU-2 & 4). An alarm should be incorporated into the BAS to alert New Haven Schools of this condition. In order to ensure adequate OA delivery using demand control ventilation, CO_2 sensors should be added to each AHU and RTU; the CO_2 setpoint should be 600 ppm to maximize OA to the space.

Not all exhaust fans are shown in the BAS, but 18 have statuses indicated. EF-6, 16, 23, 25, and 31 were shown as not running although they were commanded on by the BAS. Exhaust fan schedules should be adjusted to ensure all EFs run constantly during occupied hours.

Nurse's Suite:

The school nurse's office is located within a health suite that includes a reception area, the nurse's station, two offices, two "waiting rooms", each with a cot, and two dedicated bathrooms. At the time of the site visit, no isolation room had been identified. Once a room is identified to be converted into an isolation room, it is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Upgrade all AHU, RTU, and UV filters to MERV 13.
2. Identify an isolation room and install a HEPA-filtered negative air machine to the return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. An exhaust fan may be employed to exhaust air to the outdoors.
3. Investigate why RTU-9 is disabled. Make necessary repairs to return the unit to a properly-functioning state.

4. Investigate and repair RTU-11 disconnect.
5. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
6. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
7. Set all exhaust fans serving occupied areas to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Install a new supply connection to a nearby RTU or AHU in the janitor's office.
2. Install new return or exhaust connections to the kitchen offices.
3. Add an alarm to indicate if dampers are open less than the minimum damper position.
4. Add alarms for all comfort and indoor air quality (IAQ) variables to the BAS as well as an alarm graphic to allow for easy identification of active alarms.
5. Add school to Tritium web server to ensure alarms are captured as they arise.
6. Recommission BAS system.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Celentano Biotech, Health and Medical Magnet School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Celentano Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 13, 2020 and remote building automation system (BAS) review on October 15, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Nine air handling units (AHU), one energy recovery unit (ERV) and one makeup air unit (MAU) serve the building, installed in 2003. These units provide all of the building's outdoor air and are equipped with chilled water cooling coils and hot water heating coils. Hot water boilers and water-cooled chiller systems provide heating and cooling. Within the building, forty-five fan coil units (FCU) with chilled and hot water coils fine tune air temperature and flow to each classroom and corridors. The ERV supplies fresh air to each FCU and returns air from each classroom back to the unit. Variable air volume (VAV) boxes with hot water reheat coils fine tune AHU air temperature to the locker rooms, Nurse's suite, administration offices, special education and Library. Six exhaust fans (EF) ventilate toilet rooms, kitchen and the mechanical/machine rooms. Most of the HVAC systems are functioning during our visit.

At the time of our site visit, ERV-1 was operating. Filters were due for replacement. All air handlers were running with the exception of AHU-2, whose disconnect was set to OFF position. Filters in the all units were at end of life or damaged and should be replaced immediately.

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Observable OA dampers (AHU-3 & 7) were noted as open. Classroom FCU filters were not observable.

Building Automation System Review Findings

In general, the BAS system was found to be sparsely populated. The AHU-8 minimum outdoor air (OA) damper position is listed as 50%, while the AHU graphic shows it as closed. The AHU-4 CO_2 set point is 1500 ppm, which is too high during normal circumstances, not just during pandemic condition. For pandemic operation, 600 ppm is recommended. OA min position is 50% which probably over-ventilates the gym when it is sparsely occupied. AHU-9, which serves the Observatory 2nd floor, is not reporting data to the BAS. Four of the six exhaust fans are shown on the BAS. Exhaust fans shown on BAS do not indicate what areas are serving. The mechanical drawings indicate that the six exhaust fans serve the 3rd floor mechanical room, Kitchen, boiler/chiller room, toilet rooms, attic spaces and the elevator machine room. Only the mechanical room exhaust fan is in operation.

The air distribution system includes ducted supply with plenum return, connecting most spaces above the ceiling grid. Areas with missing ceiling tiles will directly affect the airflow to and from the affected room as well as adjacent rooms, as the return air will follow paths of least resistance into the space above the ceiling grid. Classrooms each contain one side-wall supply and one side-wall return grille, as well as hydronic finned-tube radiation (FTR). Storage Room 114 was missing a plenum return grille.

Nurse's Suite:

The 2nd floor Nurse's Suite consists of a waiting area, Exam Room, Nurse's office, Storage room, Resting Room and dedicated toilet room. The AHU-2 serving the Nurse's Suite also serves the adjacent administrative and testing rooms. Transfer ducts above the ceiling connect rooms within the suite to adjacent spaces. Resting Room 217D was identified as the isolation room during our visit. This room has a supply and transfer grille above the ceiling to the waiting area. This arrangement adheres to the minimum state mandate, but modifications are recommended below to mitigate transmission of viral particles.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air

percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

2. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
3. Set exhaust fans serving occupied areas to run constantly during occupied hours.
4. Determine reason why AHU-2 disconnect was shut off. Repair if necessary.
5. Replace all ERV and pre-filters with new MERV 8 filters or better. Replace AHU final filters and return air filters with MERV 13 or better. Replace filters in classroom FCUs.
6. Correct AHU-8 OA damper position discrepancy.
7. Replace any missing ceiling tiles to ensure proper designed air movement through the plenum returns.
8. Install a HEPA-filtered negative air machine to the isolation room's plenum return. Reduce supply air to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply diffuser and transfer grille (located above the ceiling) to create a passive isolation room appropriate for short-duration occupancy. An exhaust fan through a window or outside wall is recommended in this case and will negatively pressurize the space to prevent cross-contamination with adjacent spaces.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Install a small plenum return grille in Storage Room 114.
2. Add return air CO_2 points to all AHU's and ERV graphic in BAS to monitor ventilation adequacy.
3. Add exhaust fan status graphics for all exhaust fans in BAS.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO_2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Christopher Columbus Family Academy – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Christopher Columbus Family Academy. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations and remote building automation system (BAS) review on October 22, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Six rooftop air handling units (RTU), serve the building, installed in 2007. These units provide all of the building's outdoor air and are equipped with chilled water cooling coils and hot water heating coils. Hot water boilers and air-cooled chiller systems provide heating and cooling. Within the building, shut-off variable air volume (VAV) units with hot water coils fine tune air temperature and air flow to each classroom and corridors. The ERV supplies outdoor air to each fan coil unit (FCU) and returns air from each classroom back to the unit. Nine split system air conditioning units serve various unoccupied spaces. Twelve exhaust fans (EF) ventilate toilet rooms and other general spaces. In general, HVAC systems are functioning correctly.

RTU-1 & 2 serve the classrooms and other small zones. RTU-3, 4 & 5 serve the large assembly areas. RTU-6 serves the kitchen and works in tandem with the exhaust hood. At the time of our site visit, all RTU's with the exception of RTU-6 were operating since there were no cooking activities in the kitchen. Filters were last changed in 2019 and require replacement. We recommend replacing them with MERV 13 filters. The outdoor air (OA) dampers for RTU-2, 3, and 5 were 100% open. Return air (RA) dampers for RTU-1, 2, 4, and 6 were 100% open. With both OA and RA dampers 100% open, RTU-2 should be further inspected and re-commissioned to ensure that

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the unit is operating as intended and accurately reflected in the BAS. The belt for the RTU-3 return air fan was missing, so while the motor was running, the fan blades were not. The supply air fan for RTU-3 was making noise which indicates possible bearing or belt issue. RTU-1 has a ripped inlet screen.

There are ten exhaust fans (including the kitchen hood and another kitchen fan) that serve dedicated areas, such as toilet rooms. Exhaust fans EF-1, 3, 6, 9 & 12 were operating, while EF-2, 8, 10, and 11 were not running. Exhaust fans EF-4, 5 &7 were not located in the field or BAS. The drawings made available to us did not indicate what areas exhaust fans served.

Building Automation System Review Findings

Within the BAS, the sequence of operations is linked to the equipment graphics. While RTU's 1-5 have CO_2 values reported, only RTU-5 (GYM) uses CO_2 sensor to increase outside air beyond the minimum set point. The other RTU's utilize an economizer cycle to increase outdoor air above minimum. The cafeteria (RTU-4) should utilize CO_2 to control outdoor air, but currently does not. At the time of analysis, the CO_2 sensor readings appeared reasonable for an unoccupied building.

RTU-1 & 2 report total airflows that do not correspond well with the reported damper positions. Similarly, RTU-3 shows a very small OA airflow while both OA dampers were 100% open, indicating a problem with the flow sensors or damper positions. RTU-4 should have been operating in economizer mode given the temperature outdoor conditions. Split air conditioning units ACU-1, 2, 3 & 7 report humidity above 70%, which should report an alarm. Twenty of the 66 VAV's were evaluated, with only one (VAV122N) operating far over its setpoint.

The exhaust fans run on a time schedule, local switches or space temperature. EF-10 & 11 do not have a command signal within the BAS. The outdoor temp/humidity points read as zero, suggesting they are faulty or disconnected from the network. Trend logs appeared to exist within the BAS, but were not accessible for review.

The air supply paths include ducted supply and ducted returns. Classrooms each contain central ceiling supply diffusers and one ceiling return grille, as well as hydronic heating within the 1st floor radiant floor slab and 2nd floor radiant ceiling panels. Supply and return diffusers were noted as dirty in the Cafeteria and faculty dining, whose supply ductwork was also missing a supply diffuser.

Guidance Suite:

The Guidance Suite was noted by staff as having poor ventilation, particularly in Room 218B, which has no temperature or CO_2 sensor. Room 218B was noted as stuffy during our visit. Upon further review, the VAV box serving Room 218B (VAV 218) is controlled by a thermostat located in Room 218A (Vice Principal). As Room 218B has a large window and two occupants (an exterior room), versus Room 218A, which is an interior room with one occupant, it is recommended to

relocate the existing thermostat in Room 218A to Room 218B. The supply ductwork serving Room 218A should be rerouted to upstream of the VAV, as the heating and cooling loads of interior rooms are more consistent than those with external walls and windows. The supply grille in 218A should be replaced with a new Accutherm Therma-Fuser (or similar) with built-in thermostat to reduce airflow as needed to maintain office temperature.

Nurse's Suite:

The Nurse's Suite consists of a combined office and laydown area, a waiting area, an exam room and dedicated toilet room with exhaust fan. The exam room (Room 103C) has been designated as the isolation room, and is equipped with a supply diffuser and window. This arrangement adheres to the state mandate. The Nurse's Suite is served by RTU-2, which serves the adjacent administrative areas and lobby. Recommendations for the isolation room are included below.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
2. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
3. Re-commission RTU-2 to ensure that the unit operates properly and is accurately represented within the BAS.
4. Set exhaust fans serving occupied areas to run constantly during occupied hours. Check the belts on all fans to ensure operability.
5. Check and correct all flow measurement sensors and damper positioning sensors in RTUs.
6. Replace all filters with new MERV 13 filters or better.
7. Install a new return in the isolation room, as well as a HEPA-filtered negative air machine. Reduce supply air to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply diffuser to create a passive isolation room appropriate for short-duration occupancy. An exhaust fan through a window or outside wall is recommended in this case and will negatively pressurize the space to prevent cross-contamination with adjacent spaces.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean all dirty or clogged diffusers and grilles.
2. Replace missing supply diffuser in the faculty dining area.
3. Incorporate VAV control modifications in Guidance Suite.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Modify the BAS to show both commanded and resulting RTU OA damper positions to confirm proper operation.
3. Improve BAS trend log operability, as trend logs are a useful tool in diagnosing indoor air quality or comfort issues.
4. Conduct a ventilation analysis of each VAV system to determine the minimum outside air fraction required for each AHU and minimum VAV box damper settings to make sure every VAV zone gets adequate OA.
5. Add CO2 measurements in critical VAV zones identified in the ventilation analysis and use these measurements in conjunction with existing RA CO2 measurement to implement demand controlled ventilation that overrides minimum OA setpoints. Economizer operation should override demand-controlled ventilation.
6. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Clarence Rogers School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Clarence Rogers School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 25, 2020 and remote building automation system (BAS) review on October 6, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Four rooftop units (RTU) and twenty-six exhaust fans (EF) serve the building. All of these units were installed when the building was renovated in 2000. These units supply all of the mechanical ventilation for the school and the RTUs are equipped with hot and chilled water coils. At 20 years old, the units are nearing the end of their useful lives (typically 20 years). All RTUs were running during the site visit.

Upon inspection, the RTU filters were noted to be visibly dirty and due to be replaced. It is recommended that all final RTU filters are replaced with MERV 13 filters. Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an RTU. The Staff Lounge was noted missing a return grille. Minor short cycling concerns were raised in smaller offices, but no changes are recommended at this time.

Building Automation System Review Findings

Based on the review of the building's BAS, some re-commissioning is necessary to ensure all equipment is working as designed and supplying the building with sufficient outdoor air (OA). The building uses demand-controlled ventilation (DCV) with a CO_2 set point of 800 ppm. However, the

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DCV appears to override the minimum damper setting in RTU-1 and 4. Also, RTU-1 appears to have a faulty CO_2 sensor during the system review. The DCV function should be re-commissioned before re-opening the building and the CO_2 set point should be reduced to 600 ppm to encourage more outdoor air into the building. A minimum OA damper position should be able to override DCV.

VAV boxes are used to fine-tune air temperatures from the RTUs to occupied spaces. During the system review, some VAV boxes reported airflows inconsistent with the set points by the BAS. The VAV system should be re-commissioned as well to ensure each room is supplied with enough supply air to meet ventilation requirements.

Exhaust fans are not represented in the BAS. Their operation must be confirmed visually on-site.

Nurse's Suite:

The school does not have a dedicated nurse. Instead, the nurse splits the week between Clarence Rogers School and the Katherine Brennan School across the street. There is a nurse's office for when the nurse is in this building, which includes a reception area, an exam room, and a dedicated bathroom. At the time of the site visit, an isolation room had yet to be identified. Once a room is identified to be converted into an isolation room, it is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Re-commission RTU's DCV function to ensure mechanical ventilation requirements are met. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
2. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
3. Replace filters in all RTUs. If possible, upgrade to MERV 13.
4. Identify a suitable isolation room and install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a

negatively pressured environment. If possible, install an exhaust fan through the outside wall or window.

5. Investigate faulty RTU-1 CO_2 sensor and replace or repair as necessary.
6. Re-commission VAV system to ensure all zones are being ventilated per design and VAV box airflows are accurately reported in the BAS.
7. Confirm that all exhaust fans serving occupied spaces run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Install a return in Staff Lounge

As part of a future renovation, it is recommended to incorporate the following:

2. Replace aging RTUs.
3. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
4. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
5. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Clemente Leadership Academy - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Clemente Leadership Academy. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 29, 2020 and remote building automation system (BAS) review on October 13, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Five rooftop units (RTU), one energy recovery unit (ERV), and fourteen exhaust fans (EF) serve the building, installed in 2009. The air handling units supply all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. The RTUs are equipped with 2" pre-filters and 4" after-filters. All RTU filters were noted to be clean and appeared to have been recently replaced. The ERV filters were not accessible during the site visit, as tools were required for access. Most occupied rooms are equipped with both supply and return diffusers/grilles to provide outdoor air (OA) to/from an RTU or ERV through a fan coil unit (FCU). The only exception was the kitchen office, which was noted to have a supply diffuser but no return grille.

Building Automation System Review Findings

Based on the review of the building's BAS, some system repairs are necessary prior to re-opening the building. Most importantly in regards to ventilation, ERV-1 is showing different OA and supply air (SA) airflows, which indicates a sensor error. This unit should be inspected and repaired prior to re-opening to ensure adequate ventilation of the building. All RTU damper positions are reported in the BAS and were noted to all be at 30% OA or above.

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RTU units labeled RTAHU-1 and -2 both have supply air temperatures above their set point. However, the heating control valve indicates a closed position. It is possible that both units have either a valve leak, faulty actuator or faulty temperature sensor, which must be diagnosed and resolved prior to re-opening. In addition to high SA temperature, RTAHU-1 appears to have a faulty CO_2 sensor that should be repaired or replaced. Once all CO_2 sensors are working, the building's demand-controlled ventilation (DCV) should be used and the CO_2 set point should be 600 ppm to encourage additional OA into the building.

During the BAS review, EF-3, 5, 8, and 10 were noted to be turned off. EF-9, 13, and 14 were commanded to run, but appeared to be disabled. EF-12 had an active alarm that should be investigated and resolved. All of these fans serve toilet rooms with the exception of EF-9, which serves an electrical room. All general purpose and toilet exhaust fans should be set to run constantly during occupied hours.

Nurse's Suite:

The school's health suite includes a reception area, the nurse's office, the social worker's office, an exam room, and a dedicated restroom. Room D140 has been identified as the school's isolation room. This room is located next to the building's main entrance and has supply and return connections to ERV-1. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Upgrade RTU and ERV final filters to MERV 13.
2. Install a HEPA-filtered negative air machine to the isolation room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Investigate issues related ERV-1 flow sensors and repair system so building is ventilated as designed and is accurately represented in the BAS.
4. Investigate issues related to RTAHU-1 and 2 heating valves and replace or repair as necessary.
5. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air

percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

6. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
7. Set all exhaust fans serving occupied spaces to run constantly during occupied hours.
8. Investigate and resolve active alarm in EF-12.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Investigate faulty RTAHU-1 CO2 sensor and replace or repair as necessary.
2. Install a return grille in the kitchen office.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTAHU system to determine the minimum outside air fraction required for each RTAHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Clinton Avenue School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Clinton Avenue School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 20, 2020 and remote building automation system (BAS) review on October 22, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Nine air handling units (AHU) and sixteen exhaust fans (EF) serve the building, installed in 2005. These AHUs provide all of the building's outdoor air and are equipped with chilled water cooling coils and hot water heating coils. Hot water boiler system and air-cooled chiller system provide necessary heating and cooling. Variable air volume (VAV) boxes with hot water reheat coils fine tune AHU air temperature and flow throughout the building.

At the time of our site visit, all air handlers were running. All AHUs have MERV 8 pre-filters and MERV 11 final filters that were replaced in June 2020. The final filters should be upgraded to MERV 13 during the next scheduled filter change. All outdoor air (OA) dampers were observable except for AHU-1. AHU-2, 3, 4, and 9, were noted to have open OA filters during the visit. All occupied rooms were noted to have both supply and return connections to an AHU and should be receiving OA as long as the AHUs are running properly.

Building Automation System Review Findings

Based on our review of the BAS system, inconsistencies and failures relating to AHU fans should be investigated and corrected in order for the VAV boxes to function properly and ensure proper

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OA introduction into the building. AHU-2, 6, 7, and 8 show VFD signals that do not agree with their fan operation status. In addition, AHU-6 has an open heating valve while in cooling mode, indicating an uncalibrated valve positioner. AHU-7 has an active return fan failure alarm.

TEF-5 and 6 also have active failure alarms. EF-2 and 4 are commanded on within the BAS, but are not running.

Unrelated to ventilation demand, boiler B-1 has been shut off due to a coupling failure at HWP-3. Prior to re-opening the building, in addition to correcting VFD issues, all alarms should be investigated and corrected.

Nurse's Suite:

The Nurse's Suite consists of a waiting area, three exam rooms, and two offices. The nurse's office 127D has been identified as the isolation room. This isolation room is equipped with supply and return connections to AHU-6 as well as operable windows. The AHU-6 serving the Nurse's Office recirculates air throughout other areas within the building. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
2. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
3. Set exhaust fans serving occupied areas to run constantly during occupied hours.
4. Investigate and correct VFD/fan issues within AHU-2, 6, 7, and 8
5. Investigate and correct all active alarms in AHU-7, TEF-5 and 6, and EF-2 and 4.
6. Re-calibrate AHU-6 heating valve.
7. Replace AHU final filters with MERV 13 or better.
8. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured

environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Replace HWP-3 coupling and return B-1 to operable condition.
4. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

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- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Conte West Hills Magnet School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Conte West Hills Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 22, 2020 and remote building automation system (BAS) review on October 28, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Thirteen packaged rooftop units (RTU), four air handling units (AHU), two make-up air units (MAU), and 38 exhaust fans (EF) serve the building, which was renovated in 2000. The air handling units provide all of the mechanical ventilation for the school and are equipped with hot water coils and direct expansion (DX) cooling. Supply air is ducted to indoor spaces, while return plenums bring air back to the air handling equipment. Multiple duct-mounted hydronic reheat coils refine zone air delivery temperature.

At the time of the site visit, MAU-2, an unmarked RTU, and the vast majority of EFs were not running. It was unclear if the units were manually turned off via the BAS or if they were not functioning. The filters and dampers in all units, except RTU-1, were only accessible with tools and therefore were not observed. All filters were reported by maintenance staff to have been changed in March 2020 with new MERV 8 filters. Upon investigation, filters within RTU-1 were not dated and appeared dirty, and appeared to be less than MERV-8. RTU-1 return air (RA) damper was fully open and the outdoor air (OA) damper was fully closed. The Dectron "Dry-o-Tron," which serves the pool area, is leaking air into the mechanical space due to faulty enclosure seals.

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The cover to EF-11 was removed but was functioning. Many exhaust fans, which primarily serve science classrooms, mechanical rooms and toilet rooms, were covered in a red dust, possibly from nearby carbon steel corrosion.

Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU or RTU. Room A147 (an office) has a ceiling mounted split unit for cooling and no apparent mechanical ventilation. Mechanical drawings show a supply diffuser in this room, which was either removed or ducted into the split unit. This supply ductwork should be confirmed and, if necessary, reinstalled to provide adequate ventilation into the space. Rooms A139, A242, the School Store, and one office in the Guidance Suite have supply air but no returns. There is no ventilation in Gym Storage. Supply and return diffusers in the entrance vestibule offices are dirty and very high. The style of diffuser installed may not have adequate "throw" to provide supply air to the occupant below before returning to the air handler. Diffusers with inadequate throw also lend themselves to temperature stratification issues. Classrooms 11-15 have no return diffuser and appear to rely on returns thru cracks in the ceiling tiles. Dust in the plenum area was also setting of a duct smoke alarm.

Building Automation System Review Findings

During the review of the building's BAS system, multiple deficiencies were discovered. AHU-1 damper positions are not shown on the BAS and the return air (RA) temperature sensor and its CO_2 sensors were malfunctioning. AHU-2 and AHU-3 were not available on the BAS. AHU-4 RA CO_2 sensor was malfunctioning. RTU-1 damper positions are not shown and RTU-2 thru RTU-12 outdoor air (OA) dampers were completely shut. Most of these RTUs have malfunctioning CO_2 sensors, which might have led to closure of the OA dampers. RTU-3 was cooling despite low OA temperature. RTU-8 had a mixed air (MA) temperature lower than the OA temperature, and a supply air (SA) temperature of 302°F, indicating sensor malfunction. RTU-9 supply fan was enabled but in the off position.

All RTUs have existing demand-controlled ventilation (DCV) enabled; however, DCV cannot be achieved since the majority of CO_2 sensors are not functioning properly. RA CO_2 set points were not shown in the BAS to our understanding; it is recommended CO2 set points be set to 600ppm to ensure proper OA damper operation. The minimum OA damper position in all air handling equipment should be set to 30%.

No EFs were displayed on the BAS, but general EFs should run continuously.

Nurse's Suite:

The school nurse's office is located within a health suite that includes a reception area, the nurse's office with a cot, two offices, a conference room, and a bathroom. There will be two isolation rooms at the school, fulfilling the state mandate. Room A143 and the adjacent room will be

provided with a cot and used as isolation rooms. Both rooms are interior rooms with supplies and returns present.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Investigate physical damper position, fan status, and sensors to diagnose malfunction and communication issues within all RTUs and AHUs.
2. Set all exhaust fans to run continuously.
3. If possible, upgrade filters in all RTUs and AHUs to MERV 13.
4. In the two isolation rooms, install a HEPA-filtered negative air machine to the room plenum return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. An exhaust fan may be employed to exhaust air to the outdoors.
5. Set the AHU and RTU outdoor air dampers to allow the maximum volume of outdoor air to enter the building.
6. Set minimum OA airflow in each AHU and RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
7. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
8. Fix sensor function and communication issues to allow for Demand Controlled Ventilation. Once remedied, reduce demand controlled ventilation target range to allow for maximum OA to enter space.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean grilles/diffusers and plenum area to alleviate duct smoke alarm activation.
2. Add plenum returns to the rooms noted above, including storage areas and offices.
3. Confirm supply air into Room 147. Install supply diffuser as required and install plenum return grille.

4. Consider replacing vestibule office supply diffusers with those rated for appropriate throw at design airflows.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
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FUSS & O'NEILL

January 15, 2020

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: New Cooperative Arts & Humanities High School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the New Cooperative Arts & Humanities High School (Co-Op). The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 15, 2020 and remote building automation system (BAS) review on October 12, 2020, it is our opinion that the building's ventilation systems have significant deficiencies that will need to be corrected and re-evaluated before considering reoccupying the building. A summary of our findings and recommendations are shown below.

Field Observations

Ten indoor air handling units (AHU), and eighteen exhaust fans (EF) serve the building, installed in 2007. The air handling units provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. With the exception of AHU-7, which had new filters installed, The AHU filters were last replaced in August 2017. These filters are dirty and in need of replacement. AHU-1, 2, 3, 4, 5A, and 8 all have MERV 8 pre-filters and, per the mechanical drawings, MERV 14 final-filters. AHU-5B, 7, 9, and 10 have MERV 8 filters installed on the outdoor air intake in the pre-filter position. MERV 14 filters are installed on the return air side of the AHU, which is downstream of the outdoor air intake. These final filters are in compliance with state and industry filter recommendations and should be replaced in kind when at end of life.

With the exception of AHU-3 and AHU-4, which had an outdoor air damper that appeared to be mostly closed, all AHUs were observed to have open outdoor air (OA) dampers. AHU-8 was noted to have a damaged OA damper that should be repaired. Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU. Gym office S031, administration office S130, mail room S130B, security office S131 and instrument workshop N226 do not have return, exhaust, or transfer grilles. Room S130D is a storage room being used as an

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office with no supply or return connections. Damaged grilles and diffusers were noted in the gym and locker room areas.

Building Automation System Review Findings

During the review of the building's BAS system, most of the AHUs were in operational condition; however, there are some damper position issues that will need to be addressed. AHU-1 OA, return air (RA), and exhaust air (EA) damper positions are all shown at 15%, which is not a correct configuration (OA and RA damper positions should add up to 100%). AHU-2 and AHU-8 have the same issue as AHU-1. AHU-3 OA, RA, and EA damper position are all shown at 100%, which is also not correct. AHU-5 and AHU-5A have the same issue as AHU-3.

Demand controlled ventilation is possible in all AHUs through return air CO_2 sensors, and CO_2 set points should be lowered to below 600 ppm to maximize AHU OA damper position while setting the minimum OA damper setting to 30% open. The return air CO_2 sensors on AHU-1, 4, 5A, 8, and 10 had readings of 0 ppm during the system review. AHU-5 had a high reading of 1983 ppm. These sensors appear to be malfunctioning and should be inspected.

All general and toiler room exhaust fans were enabled in the BAS. However, EF-2, 3, 7, 8, 9, 10, 15, and 16 were not running despite being enabled. Prior to reopening, all general and toilet room exhaust fans should be running constantly without alarms during occupied mode.

Nurse's Suite:

The school nurse's area includes a large reception area, an office, and a dedicated bathroom. The Nurse's Office (N201A) is being converted into the school's isolation room with two cots. This room has supply and return diffusers/grilles, and is located on an outside wall. The air from this room is recirculated through the surrounding administrative areas. This arrangement meets the state mandates for pandemic emergency. Additional recommendations for isolation room modifications are below.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Investigate physical damper position, fan status, and sensors to diagnose malfunction within all air handling units.
2. Set the AHU outdoor air dampers to allow the maximum volume of outdoor air to enter the building during shoulder season. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the

basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

3. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
4. Investigate alarm associated with EF-2, 3, 7, 8, 9, 10, 15, and 16.
5. Set all general or toilet exhaust fans to run 24/7.
6. Install a HEPA-filtered negative air machine to the isolation room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. An exhaust fan may be employed to exhaust air to the outdoors.
7. Replace/repair all return duct CO_2 sensors.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace damaged grilles/diffusers in rooms listed above.
2. Install new supply and return ductwork in Room S130D. Connect to a nearby AHU in room S130D.
3. Install return ductwork in rooms S031, S130, S130B, S131 and N226.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
- Center for Disease Control, Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation, September 22, 2020
- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Davis Street School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Davis Street School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 13, 2020 and remote building automation system (BAS) review on October 14, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Ten rooftop units (RTU), two energy-recovery ventilators (ERV), ten exhaust fans (EF), and a make-up air unit (MAU) serve the building, installed in 2010. These units provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. The RTUs and ERVs are equipped with MERV 8 filters that were replaced in June 2020. With the exception of ERV-2, which had dirty filters despite the recent replacement, the filters appeared to be clean and undamaged. The outdoor air dampers on all RTUs and ERVs appeared to be open with the exception of ERV-1, which only had 25% of the available damper blades open. This unit should be inspected further to confirm that the damper linkage is operating correctly.

All occupied rooms are equipped with both supply and return grilles to provide airflow to/from an RTU with the exception of the Coach's Offices next to each locker room. Both Coach's Offices have supply diffusers, but the only return/exhaust grilles are in the adjoining bathrooms, which are separated by a door.

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Building Automation System Review Findings

During review of the building's BAS system, all RTUs were running. All RTUs have existing demand-controlled ventilation (DCV). RTU-1 and 8 currently utilize DCV, but have high CO_2 set points. It is recommended that the DCV be utilized and the CO_2 set point be adjusted to 600 ppm. Minimum outdoor air (OA) damper positions should be set to 30% open to ensure ventilation during occupied hours, even if the CO_2 concentration drops below the set point. The outdoor air temperature and CO_2 sensors on RTU-1 and 9 appear to be damaged or improperly calibrated and should be fixed prior to re-opening to ensure proper operation. All other equipment appears to be functioning properly.

Nurse's Suite:

The school Nurse's Office is located within a health suite that includes a reception area, a laydown area with three cots, each with a curtain, offices for the school social worker, nurse practitioner, and health educator, a conference room, and a bathroom. The Health Educator's Office (Room 122J) is being converted into the school's isolation room. This room is equipped with supply and return grilles and is located on an outdoor wall. The room is conditioned and ventilated by RTU-7, which also serves and recirculates air throughout the rest of the health suite as well as the main office area on the first floor. This arrangement satisfies the state's mandates. Additional recommendations for the isolation room are below.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Upgrade filters in all RTUs and ERVs from MERV 8 to MERV 13.
2. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Set the RTU outdoor air dampers to allow the maximum volume of outdoor air to enter the building during the shoulder season.
4. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
6. Set all general exhaust fans serving occupied areas to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Inspect ERV-1 outdoor air damper linkage and blade operation. Repair if necessary.
2. Replace or re-calibrate outdoor air temperature and CO_2 sensors in RTU-1 and 9.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
3. Install return/exhaust ducts in the coach's offices.
4. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

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- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: East Rock Community Magnet School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the East Rock Community Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 20, 2020 and remote building automation system (BAS) review on October 25, 2020, it is our opinion that the building's ventilation systems have some deficiencies and will need to be addressed before the building can be reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Seven indoor air handling units (AC) serve the building, installed in 2013. These units provide all of the building's outdoor air and are equipped with chilled water cooling coils and hot water heating coils. Chilled beams, fan coils units (FCU), and variable air volume (VAV) boxes with hot water reheat coils fine tune temperature and flow throughout the building. Some areas are supplemented with cabinet unit heaters, unit heaters, and fin tube radiation.

At the time of our site visit, AC-1 was running and was observed to have dirty filters in need of changing. AC-6 was observed to be running and appeared to have new MERV 8 pre-filters and MERV 14 post-filters. The other five ACs were not accessible during the site visit. The final filters should be upgraded to MERV 13 in all units. Outdoor air (OA) dampers were observable on AC-1 and AC-6 and were noted to be partially open and fully open respectively. The majority of occupied rooms were noted to have both supply and return duct connections to an AC and should be receiving OA as long as the ACs are operating as designed. Room 120 was noted to have a supply diffuser but no return in the room. Returns in some of the basement-level classrooms are located directly above storage cabinets and may be blocked by storing supplies and boxes on top of the

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cabinets. Any supplies or boxes blocking return grilles should be moved to allow airflow into the grille.

Building Automation System Review Findings

Based on our review of the BAS, many of the AC system settings and equipment conditions require review. The occupancy schedule was not available through the BAS. During the review, AC-1 was running on "Summer Mode" with the OA damper at 40% open, the return air (RA) damper at 80% open, and the exhaust fan off. This RA damper position and exhaust fan status conflicts and indicates that the unit control is off or damper/fan is not operational. AC-2 has an exhaust fan which was enabled but not running, there were also dirty filter alarms for the OA and mixed air (MA) filters. AC-3 OA damper was closed and both the exhaust and supply fans were off. This unit was observed to have an open OA damper during the field visit. The damper position should be physically checked against what is reported in the BAS to ensure proper communication. AC-3 discharge temperature exceeded the set point due to a chilled water system failure. AC-4 and AC-5 both had a dirty OA filter alarm and the discharge temperature was higher than the set point. AC-6 and AC-7 were both on "Summer Mode". All exhaust fans (EF) were disabled. EF-10 and EF-15 status should be investigated as they were shown to be "on" even though they were disabled. Some of the FCUs were on and some were off. The temperature settings for these units should be verified. Global points such as the outdoor air temperature and outdoor air relative humidity readings were not consistent with weather data and sensors should be recalibrated or replaced.

Demand control ventilation is possible for the air handling units, as CO_2 sensors are located in the return ductwork as well as in most rooms. During the review, the return air CO_2 set points were between 700 and 2000ppm. It is recommended that this set point be lowered to 600ppm to maximize outdoor air damper position.

At the time of the BAS review, the hydronic heating system and all supplemental heating units were off. There is only one chiller serving the building and the BAS indicated that it was enabled but in "failure" mode. Since the chiller was not functioning, the chilled water temperature exceeded the set point resulting in the discharge temperature of AC systems being too high.

Nurse's Suite:

The Nurse's Suite consists of a waiting area, two offices, a storage room, and a dedicated bathroom. The "Dream Den", office 016, has been identified as the isolation room. This isolation room is equipped with supply and return connections to AC-4. The AC serving the isolation room recirculates air throughout other areas within the building. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations:

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode.
2. Recommission the air handling equipment so that the damper positions follow the sequence of operations and are accurately reflected in the BAS.
3. Set exhaust fans serving occupied spaces to run constantly during occupied hours.
4. Prior to re-opening the building, AHUs should be set to maximize OA capacity as weather and CO_2 set points allow without freezing coils and compromising occupancy comfort.
5. Re-calibrate Global point sensors such as the outdoor air temperature and outdoor air relative humidity sensors.
6. Replace AHU final filters with MERV 13 or better and ensure no filter alarms remain.
7. Set minimum OA airflow in each AC to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
8. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
9. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Investigate and correct chiller "failure" alarm.
2. Review and correct FCU temperature settings.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.

2. Add CO_2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help mitigate the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachment:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
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- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Edgewood Magnet School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Edgewood Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 20, 2020 and remote building automation system (BAS) review on October 29, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and code violations that will need to be corrected, and re-evaluated before considering re-occupying the building. A summary of our findings and recommendations are shown below.

Field Observations

Six air handling units (AHU), six rooftop units (RTU), and two air conditioning units (ACU) serve the building, which was renovated in 1999. These units are equipped with direct expansion (DX) cooling coils and hot water heating coils. All of these units are approaching the end of their useful lives (typically 20 years) and should be replaced in the near future. Some areas are supplemented with cabinet unit heaters.

At the time of our site visit, most HVAC equipment was not running. With limited BAS information and no as-built drawings, it is difficult to identify which units serve occupied spaces. However, all units serving occupied spaces should be operating during occupied hours to provide mechanical ventilation to the building.

Filters and other internal components were not accessible in any unit during the visit with the exception of ACU-1, which was equipped with MERV 7 filters that were noted to be dirty and in need of replacement. The final filters of all units should be upgraded to MERV 13 where possible.

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The outdoor intake screen of RTU-1 and RTU-2 are clogged and need to be cleaned. RTU-1 had a torn outdoor air intake screen in one corner. All occupied rooms were noted to have both supply and return connections to the air handling equipment.

Building Automation System Review Findings

Based on our review of the BAS, the system lacks information and is need of an update. Some of the air handling equipment requires attention. Not all air handling units or terminal units are available for viewing in the system. Floor plans and room temperature readings were not available in the BAS. The outdoor air temperature was 46°F at the time of the review. AHU-1 OA damper status according to the BAS was open; however, the return air (RA) temperature was the same as the mixed air (MA) temperature of 64°F which suggests that the OA damper is not actually open. AHU-2 through AHU-5 were not available on the BAS. The majority of RTUs and ACUs have OA damper positions between 30% and 52% open, with the exception of RTU-3 and RTU-5 which were closed. The occupancy schedule was not available on the BAS. There are six exhaust fans (EF). EF-1, EF-4, and EF-5 are operating. EF-2, EF-3, and EF-6 are enabled but in the off position with alarm in the BAS and need to be checked. Unrelated to ventilation demand, hydronic heating was operating as expected and all supplemental heating units were off due to the lack of demand for heat.

Nurse's Suite

The Nurse's Suite consists of a main exam/waiting area, an office, and a dedicated bathroom. Storage room B004 has been identified as the isolation room. This isolation room is equipped with supply and return connections to ACU-1. ACU-1 recirculates air throughout other areas within the basement including the nurse's suite and library. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
2. Set all exhaust fans serving occupied spaces to run constantly during occupied hours.

3. Prior to re-opening the building, RTUs and AHUs should be set to maximize OA capacity as weather allows, typically in spring and fall seasons (economizer mode).
4. Investigate and correct damper positions within AHU-1, RTU-3, and RTU-5
5. Investigate and correct all active alarms in EF-2, -3, and -6.
6. Replace AHU and RTU final filters with MERV 13 or better.
7. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Update the BAS to show all air handling and terminal units.

As part of a future renovation, it is recommended to incorporate the following:

1. Units approaching the end of their useful lives (20 years) should be replaced.
2. CO_2 sensors should be installed in the return air ducts of each unit providing ventilation to allow for demand-controlled ventilation. A set point of 600 ppm should be implemented to ensure maximum OA ventilation.
3. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
4. Add CO_2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
5. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 in the building.*

Please don't hesitate to reach out with any questions.

Sincerely,

lient\Edgewoo

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
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- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
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- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Elm City Montessori School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Elm City Montessori School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable ventilation code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

This building is owned by a third party and leased to the City of New Haven. It is our understanding that the building owner has retained ductwork cleaning services as well as testing and balancing services prior to our evaluation. The school has a building automation system (BAS) in place that is not connected to the New Haven Schools controls package and was not made accessible to us. The building owner also reported that they are having trouble obtaining drawings from the City's building department for a planned expansion project, and, as such, no drawings were available for our review.

Based on our field observations on October 20, 2020, it is our opinion that additional information, including as-built drawings, maintenance logs, testing and balancing report retained by the building owner, as well as remote access to the building automation system (BAS) will be needed for Fuss & O'Neill to determine if the building can be occupied.

A summary of our observations and recommendations based on our field visit are shown below.

Field Observations

Twenty-eight packaged rooftop units (RTU) with DX cooling and natural gas heating serve the building. During the visit, none of the filters or outdoor air dampers were observable, as tools were required to open each unit and no maintenance personnel were available on-site. These units were installed in approximately 1998, and should be considered for replacement, as they have exceeded their 15 year life expectancy. It was reported that these units are maintained by an HVAC contractor on a monthly basis. If possible, it is recommended that the final filters are upgraded to MERV 13 in each RTU. All occupied rooms in the building appeared to be equipped with supply and return connections to an RTU with the exception of the Nurse's Office, which was noted to

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only have a supply diffuser, and the isolation room, which was noted to only have a return or exhaust grille.

Nurse's Suite

The Nurse's Suite consists of an office, cot room and two toilet rooms with dedicated exhaust. The cot room has been identified as an isolation room, and is equipped with one return grille as well as operable windows. It is recommended that a HEPA-filtered negative air machine be installed in the room's return duct.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Provide as-built drawings, maintenance logs, TAB report, and remote BAS access to F&O for review.
2. Set all general purpose exhaust fans to run constantly during occupied hours.
3. Review all available controls points for alarms or malfunctioning sensors.
4. If possible, replace RTU final filters with MERV 13 or better.
5. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period.
6. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
7. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
8. Install a HEPA-filtered negative air machine to the isolation rooms' return duct. If a HEPA-filtered negative air machine is not able to be acquired, block off return grille to create a passive isolation room appropriate for short-duration occupancy. An exhaust fan through a window or outside wall is recommended in this case and will negatively pressurize the space to prevent cross-contamination with adjacent spaces.

As part of a future renovation, it is recommended to incorporate the following:

1. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.
2. Plan for replacement of existing RTUs.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
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- ASHRAE Filtration and Disinfection FAQ
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 12, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Engineering & Science University Magnet School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Engineering & Science University Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 15, 2020, and remote building automation system (BAS) review on October 28, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Four dedicated outdoor air units (DOAU), five air handling units (AHU), and seventeen exhaust fans (EF) serve the building, installed in 2017. These units provide all of the mechanical ventilation for the school. Both the DOAUs and AHUs are equipped with hot water heating coils and chilled water cooling coils. The DOAUs are additionally equipped with energy recovery wheels (ERC) and a cooler, dryer, and quieter wheel (CDQ). At the time of the site visit, AHU-4 as well as EF-5, 6, 7, and 8 were not running. AHU-4 should operate while the building is in occupied mode as it serves the building's lobby. All general and restroom exhaust fans should run continuously while the building is in occupied mode. EF-5 had a loose cover.

The filters in all air handling equipment were in the process of being changed while Fuss & O'Neill personnel were on-site. Pre-filters and post-filters were being upgraded to MERV-13 and 14 respectively. All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU or DOAU. Diffusers in the Kitchen Area and the Admin Area of Room 213 were dirty and in need of cleaning. Rooms 312A, 412L, and 518A were found to have the locations of the diffuser and return too close together.

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Building Automation System Review Findings

During the review of the building's BAS, most of the equipment was found to be relatively new with detailed controls; however, some issues were discovered. DOAU-1 and the DOAU-4 ERC were found to have dirty filter alarms. Although the filters were being changed during the site visit, it is possible that some units have yet to receive new filters. It should be confirmed that these units have had new filters installed; if that is the case, the dirty filter alarms likely have faulty sensors that should be replaced or repaired.

DOAU-3 supply fan was enabled but in the off position with an active alarm. AHU-1 had a mixed air (MA) temperature reading lower than the outdoor air (OA) temperature. It also had a discharge air (DA) temperature of 90°F. It is recommended to have AHU-1 serviced and those specific sensors checked and calibrated. AHU-2 indicated the OA damper position to be fully closed, however the MA temperature indicated that it may be partially open. The AHU-4 OA damper was shown as fully closed, the return air (RA) damper at 67% open, and the exhaust air (EA) at 100% open. These damper positions were found to be incorrect, inconsistent and should be investigated. AHU-5 indicated the OA damper was fully closed. OA dampers should be open to the greatest extent possible to promote fresh air exchange in served spaces. CO_2 sensors are present in all ductwork which allow for demand controlled ventilation. Target CO_2 levels should be lowered to 600ppm as the current range is 600-1000ppm.

During the BAS review, EF-10 and EF-11, which serve the gym, were off. It is recommended that these fans run at all times. Additionally, all EFs serving the mechanical spaces (EF-12, -13, -14, -15, -16, and -17) were turned off. During the site visit it was found that as soon as air conditioning turns off the heat turns on. It is recommended that these settings be reviewed for temperature dead band issues. Beyond ventilation issues, boiler B-1 was in alarm status and a hot water supply temperature alarm was present.

Nurse's Suite

The school nurse's office includes a bathroom, an office, and a combination office/laydown/exam/waiting room. The office (215A) has been identified as the building's isolation room. This room has a supply connection from a DOAU and a transfer grille to the main nurse area. It is recommended that the supply diffuser and transfer grille be closed off and a HEPA-filtered air unit be installed within the isolation room.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Continue the upgrade of filters in all DOAUs and AHUs to MERV 13.

2. Close off isolation room supply diffuser and transfer grille. Install a portable HEPA filter unit within the room. If a HEPA filter unit cannot be obtained, seal off supply and transfer grilles to create a passive isolation room for short occupation.
3. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
4. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
5. Confirm that DOAU-1 and 4 have had new filters installed. If so, confirm dirty filter alarm status and repair or replace sensors as necessary.
6. Investigate physical damper position, fan status, and sensors to diagnose malfunction within AHU-1, 2, and 4.
7. Set all exhaust fans serving occupied spaces to run continuously during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace missing ceiling tiles.
2. Investigate alarms associated with B-1, DOAU-3, and the hot water supply temperature.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone AHU system to determine the minimum outside air fraction required for each AHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
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- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Fair Haven Middle School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Fair Haven Middle School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 22, 2020 and remote building automation system (BAS) review on October 23, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Eight packaged rooftop units (RTU), three indoor air handling units (AHU), and thirty four exhaust fans (EF) serve the building, installed in 2002. These units provide all of the mechanical ventilation for the school and the air handling units are equipped with hot water coils and DX cooling. Fan-powered variable air volume (VAV) boxes fine tune air delivery temperature to each zone.

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At the time of the site visit, RTU-2 and 3 were not running. These units serve classrooms, and should be scheduled to run during all occupied hours. In addition to the RTUs, EF-11, 13, 17, 20, 21, 23, 25, and 26 were not running. EF-11 and 17 were missing their covers and EF-17 was missing its belt. These exhaust fans serve toilet rooms, mechanical spaces, the kitchen, kiln, dark room and science classrooms. All general or toilet room exhaust fans should run continuously during occupied hours. The filters and outdoor air (OA) dampers in RTU-7 and 8 were not accessible during the site visit. The accessible AHUs and RTUs all had MERV 8 filters installed. These filters were not dated, but all appeared to be clean and undamaged. The position of the OA dampers within the RTUs were not readily visible during the site visit. The AHU-1 & 2 OA dampers were open, while the AHU-3 OA dampers were closed.

Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU or RTU. The Digital Arts room does not have a return grille. Return grilles in Rooms 235 and 219 were noted to be in need of cleaning. Room G05 supply has a loud rattle, indicating a loose damper or other mechanical issue.

Building Automation System Review Findings

During the remote review of the BAS on October 22, 2020, some of the AHUs require attention. Outdoor air (OA) damper for AHU-3 is set at 10%. Outdoor air damper position for RTU-1 thru RTU-8 are not shown in BAS. Prior to re-opening the school, all RTUs should have their OA intake maximized to the extent possible without freezing the coils or affecting occupant comfort. All AHUs have existing demand controlled ventilation, but are currently set between 800 and 1000 ppm. The return air CO_2 set points should be reduced to 600 ppm prior to re-opening the building. The minimum position of all OA dampers should be set to minimum 30% to ensure minimum ventilation during occupied hours. During the site visit, it was noted that RTU-4 was not responding to the outdoor air temperature sensor. All sensors should be confirmed to be properly connected prior to re-opening the building. During the BAS review, EF-20 and 21 were enabled, but not running. All EFs should be re-inspected to make sure they are operable, as additional EF's were not running during the site visit. All AHUs and RTUs are set to operate as "occupied" from 4am to 10pm seven days a week.

Nurse's Suite

The school nurse's office is located within a health suite that includes a reception area, the nurse's office, two exam rooms, the social worker's office, the nurse practitioner's office, a meeting room, two dedicated bathrooms, and a lab. The social worker's office is being converted into the school's isolation room. This arrangement adheres to the state COVID-related mandates. This room has supply and return connections to RTU-2, which recirculates air throughout the entire southeast portion of the building. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. If possible, upgrade filters in all RTUs and AHUs to from MERV 8 to MERV 13.
2. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

3. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode. Modify schedules to prioritize economizer function.
4. Set minimum OA airflow in each RTU/AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
6. Confirm RTU-7 fan belts and bearings are maintained properly.
7. Investigate EF-11, 13, 17, 20, 21, 25, 26, and 27, which were all not running during the site visit.
8. Confirm design airflows are reaching Classroom 321. Consider adding an additional fan-powered VAV box.
9. Confirm all sensors are properly connected, such as the OA temperature sensor on RTU-4.
10. Set all general purpose exhaust fans to run continuously during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean return grilles in Rooms 235 & 219.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU or AHU system to determine the minimum outside air fraction required for each RTU and AHU and minimum VAV box damper settings.
3. Relocate diffuser and return grilles at least 10' apart, if possible, in the School Store to maximize OA mixing.
4. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Hill Central School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems Hill Central School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 29, 2020 and remote building automation system (BAS) review on October 29, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Three indoor air handling units (AHU), one heat recovery ventilator (HRV), two dedicated outdoor air units (DOA), and seven exhaust fans (EF) serve the building, installed in 2011. These units supply all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. The AHUs are equipped with MERV 8 filters that were labeled to have been replaced in June 2020. Both DOA units are equipped with MERV 8 pre-filters and MERV 14 final filters. These were last replaced in August 2018 and September 2017, respectively. The HRV filters were not accessible at the time of the site visit.

It is recommended that all AHU filters are replaced with MERV 13 or greater and that all DOA filters are replaced due to age. If the HRV filter rating is below MERV 13, the filters should be replaced with MERV 13 filters, if possible. Most occupied rooms are equipped with both supply and return diffusers/grilles to provide outdoor air (OA) to/from one of these units. The principal's office was noted to have a supply diffuser but no return grille. Both the gym and kitchen cafeteria were noted to have dirty/clogged return grilles.

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Building Automation System Review Findings

Based on the review of the building's BAS, some system repairs are necessary prior to re-opening the building. All three AHUs had active alarms and return air (RA) and OA damper positions reported as 50% and 2%, respectively, which indicates the damper positions are incorrect or sensor malfunction. AHU-1 and 3 did not appear to be running as their supply duct static pressure read 0.0". AHU-2 had the same damper issues, but reported a non-zero static pressure, indicating that the unit was running. Prior to re-opening, it is recommended that the functionality of the dampers be investigated and repaired as necessary and the alarms are resolved.

The AHUs have the capability to use demand-controlled ventilation (DCV). It is recommended that DCV be used where possible and the CO_2 set point set to 600 ppm to ensure maximum OA. The minimum position of OA dampers should be set to 30% to ensure constant ventilation during occupied hours regardless of CO2 sensor satisfaction. Circulating fans CF-1 and 3 both had active alarms during the system review. EF-3 was commanded on by the BAS, but was not running. All general and restroom exhaust fans should run constantly during occupied hours. VAV-103, 104, and 105 all reported zero airflow, but also a 100% open damper.

Nurse's Suite

The school's health suite includes a reception area, a laydown area, the nurse's office, two social workers' offices, an exam room, a lab, and a dedicated restroom. Conference room 101A has been identified as the building's isolation room. This room has supply and return connections to DOA-1 and operable windows. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply be sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace dirty DOA-1 and 2 filters.
2. If possible, replace all AHU and HRV filters with MERV 13 or greater.
3. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
4. Investigate AHU set points, damper positions and active alarms. Make repairs as necessary.
5. Investigate and resolve active alarms in CF-1 and 3.

6. Investigate VAV-103, 104, and 105 flow sensors and dampers and repair or replace as necessary.
7. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
8. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean dirty/clogged return grilles in the gym and cafeteria.
2. Install a return grille in the principal's office.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone AHU system to determine the minimum outside air fraction required for each AHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
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- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Worthington Hooker School (K-2) - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Worthington Hooker School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 20, 2020 and remote building automation system (BAS) review on October 29, 2020, it is our opinion that the building's ventilation systems have significant deficiencies that will need to be corrected and re-evaluated before reoccupying the building. A summary of our findings and recommendations are shown below.

Field Observations

Two indoor air handling units (AHU), and eight exhaust fans (EF) serve the building, installed in 2006. All general purpose EFs were running. Three louvers with individual motorized dampers are connected to each AHU for the purpose of serving outdoor air (OA) to each unit. These units provide most of the mechanical ventilation for the school and are equipped with hot and chilled water coils. Variable air volume boxes (VAV) fine tune air temperature delivered to each classroom with hot water heating coils. Three unit ventilators (UV) provide ventilation, heating and cooling to the Multi-Purpose Space (Room B24). The outdoor air dampers on the unit ventilators were not accessible during our visit.

The AHU MERV 8 filters were noted to be dirty and in need of replacement. AHU-2 was noted to be missing some filters, allowing for unfiltered air to enter the ventilation system. Both AHUs were noted to be running and have open OA dampers. Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU. The Teachers' Lounge (Room 216) does not have a return or exhaust grille.

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Building Automation System Review Findings

Based on the remote review of the BAS, both AHUs require attention prior to reopening the building. The AHU-1 graphic shows all zero values in the BAS, indicating controller issues as the unit was operational during the site visit. The AHU-2 return fan is off despite being commanded on in the BAS. The BAS also only shows 89 cfm of OA in AHU-2, which does not agree with our observations in the field. Both AHUs use demand-controlled ventilation. It is recommended that the CO_2 set point is adjusted to 600 ppm to ensure OA will be supplied to the building at all times. The minimum OA damper position should be set to 30% to ensure constant ventilation, even if the CO_2 drops below the set point. The building's zone temperatures are all near their set point, but the VAV graphics show airflows far below their set points. This could be due to mild outdoor conditions. We recommend confirming VAV flow sensor operation during colder weather.

Nurse's Suite

The school nurse's area includes a waiting room, the social worker's office, a bathroom, and the nurse's office, which also serves as the exam room and cot area. The nurse's office has been identified as an isolation room. It is not clear where the non-isolation exam room/cot area will be relocated to. The isolation room has supply and return connections to AHU-2 as well as operable windows. AHU-2 also recirculates air throughout the entire west wing of the building. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace all AHU filters and upgrade to MERV 13 where possible.
2. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Investigate physical damper position, fan status, and sensors to diagnose malfunction within all air handling units.
4. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
6. Set all exhaust fans serving occupied spaces to run constantly during occupied hours.
7. Confirm that a non-isolation nurse's area has been identified prior to re-opening the building.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Troubleshoot or replace AHU-1 controller to ensure all points are represented correctly in BAS.
2. Troubleshoot AHU-2 return fan.
3. Troubleshoot or replace VAV flow sensors. Balancing will be needed to ensure reported airflows are accurate.
4. Install return grilles in Teachers' Lounge 216.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV box to determine the minimum outside air fraction required for each AHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Worthington Hooker School (Grades 3-8) - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Worthington Hooker Middle School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building.

Based on our field observations on October 20, 2020 and remote building automation system (BAS) review on January 12, 2021, it is our opinion that the building's ventilation systems have some deficiencies and will need to be addressed before the building can be occupied. A summary of our findings and recommendations are shown below. A list of guidance documents is included as *Appendix A*.

Field Observations

One indoor air handling unit (AHU), one energy recovery ventilator (ERV), five packaged rooftop units (RTU) and twelve exhaust fans (EF) serve the building, installed in 2008. These units provide all of the mechanical ventilation for the school. The AHU serves the Media Center. The ERV serves the classrooms, and the RTUs serve the large assembly areas, such as the Gymnasium, Cafeteria and Auditorium. The EFs serve the toilet rooms, janitor closets, machine rooms and Media Center. Fan coil units (FCU) fine tune classroom delivery air temperature from the ERV via chilled and hot water coils. Both the AHU and ERV units were noted to be operational during the site visit.

The ERV MERV 8 filters that were noted to be dirty or damaged and in need of replacement. The AHU filters were in good condition. The age of the filters is unknown. Both the ERV and AHU are equipped with hot and chilled water coils and were noted to have open OA dampers. Neither the RTU filters nor OA dampers were accessible during the school visit. All RTUs are equipped with DX cooling and natural gas heating. All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU. The FCUs were unobservable due to

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their location, thus their filter status is unknown. All return grilles in the library were noted to be very dirty and should be cleaned before the building is re-opened.

Building Automation System Review Findings

Connection to the BAS was restored in mid-November. Based on the remote review of the BAS, the system requires some attention prior to re-opening the building. At the time of review, RTU supply air temperatures read 0.0°F, indicating faulty sensors. The ERV and RTUs have internal factory controls and have minimal data points available within the BAS. Outdoor air (OA) damper positions are listed for the RTUs and range from 0-20% open. There are no CO2 sensors associated with the RTUs, indicating demand-controlled ventilation is not available. OA damper positions should be able to be set at the RTUs themselves and should be set to a minimum of 30% open.

The AHU reported an OA damper position of 10% open and does have DCV capabilities with return air (RA) CO2 sensors installed. It is recommended that DCV is utilized and the CO2 set point be adjusted to 600 ppm. A minimum OA damper position should also be set to 30% to ensure ventilation during all occupied hours.

The FCUs that are served by the ERV are currently set to close their OA dampers when room-level occupancy sensors do not indicate occupancy. In order to provide maximum ventilation to the building, this setting should be changed within the sequence of operations so OA is provided to the spaces during all occupied hours, even if the room is empty.

Nurse's Suite

The school nurse's area includes a vestibule, a waiting area/cot area, an office, a dedicated bathroom, and a storage room. Office 103.2 has been identified as an isolation room, and utilizes supply and return connections to fan coil unit FC-1, fed from the ERV. This FCU recirculates air within the suite and Conference Room 102. Outdoor air from ERV-1 is fed to FC-7 and exhausted via return ductwork back to ERV-1. Recommendations for the isolation room ductwork and controls modifications are below.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace all AHU filters and upgrade to MERV 13 where possible.
2. Isolation room recommendations include the installation of a motorized damper on the return duct to FC-7 (located just downstream of the isolation room return) to allow the control of return air recirculation back to the spaces served by FC-7. This new damper may

be open during times when the isolation room is not occupied. The existing motorized outdoor air (OA) damper should be maintained fully open. A HEPA-filtered negative air machine should be installed in the room's return grille and the supply-side volume damper partially closed to ensure a negatively pressured environment within the isolation room.

3. Set RTU OA dampers to a minimum position of 30% open unless the OA temperature drops too low.
4. Replace faulty RTU supply air temperature sensors.
5. Enable DCV within AHU-1 and adjust the CO_2 set point to 600 ppm. Set the minimum OA damper position to 30% open.
6. Adjust the sequence of operations to keep FCU OA dampers open independent of the room-level occupancy sensors.
7. Change filters within FC units.
8. Schedule all exhaust fans to run constantly 24/7.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean Library grilles/diffusers and associated ductwork.
2. Provide interfaces to ERV and RTUs with factory controls to display important variables and allow remote control from the BAS.

As part of a future renovation, it is recommended to incorporate the following:

1. Conduct a ventilation analysis of each FCU and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum FCU OA damper settings.
2. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.
3. Install additional CO_2 sensors throughout the building to allow for better monitoring of ventilation quality.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: High School in the Community - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the High School in the Community. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 27, 2020 and remote building automation system (BAS) review on November 5, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and will need to be corrected and re-evaluated before considering re-occupying the building. At the time of writing this report, no mechanical drawings of the building have been made available to us. A summary of our findings and recommendations are shown below.

Field Observations

Twenty eight packaged rooftop units (RTU), one make-up air unit (MAU), and one energy recovery ventilator (ERV) serve the building. The RTUs were installed between 2009 and 2017, with a majority installed in 2017. The RTUs are equipped with DX cooling and natural gas heating. While there are 28 RTUs, they are numbered 1-34, A-D. At the time of the site visit, RTU-C, 6, 7, 11, 18, 28, 33, and 34 were not running. RTUs serving occupied spaces should be run during occupied hours to ventilate those spaces. Without drawings, it is unclear which zones are served by these units.

The filters and outdoor air (OA) dampers in all of the units were inaccessible during the site visit. During the site visit, most of the roof-mounted exhaust fans were not running. All exhaust fans serving occupied spaces should be scheduled to run constantly during occupied hours. The exhaust fan in the men's staff bathroom by the Cafeteria was not working. The exhaust fan in Courtroom Restroom #2 was noted to be in working condition, but had been removed from the ceiling. This fan should be re-installed in the ceiling prior to re-opening the building.

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Most occupied rooms are equipped with both supply and return diffusers/grilles capable of providing airflow to/from an RTU. The library offices, and business manager office, as well as classrooms A104 and A105 have supply diffusers, but no return grilles. Room A109 has a return grille, but it is obstructed by stacked classroom supplies. Both the Workout Room and Nurse's office have neither supply nor return connections. Damaged diffusers were noted in the Gym and Cafeteria and should be replaced.

Building Automation System Review Findings

Based on our remote review of the BAS, the majority of the units require attention. During the review, RTU-5 and 6 were not running. RTU-11, 13, 15, 19, 29, 32, A, B, and D were running, but are shown to have their outdoor air (OA) dampers closed. Faulty sensors throughout the system must be investigated and replaced or repaired. For example, RTU-31 shows an impossible OA damper position of 127%. CO_2 sensors in RTU-18 and 31 read impossibly high values. RTU-31 shows unrealistically high readings for its mixed air and supply air temperatures.

All units display a CO_2 reading, but only RTU-9, 10, A, B, and D have CO_2 set points. The software should be revised to allow for demand-controlled ventilation in all RTUs, as all necessary inputs and outputs are already present. In cases where a set point was present, the set points were high, in excess of 1000 ppm. CO_2 set points should be reduced to 600 ppm to ensure the maximum volume of OA enters the building. The minimum position for all OA dampers should be set to 30% to ensure ventilation even if CO_2 levels drop below the set point and the mix air temperatures are satisfied.

Exhaust fans are not represented in the BAS.

Nurse's Suite

The school nurse's area is only one office. At the time of our visit, hard-walled cubicles were being built to serve as isolation areas within Room C203. These cubicles have screen doors and partitions that do not extend to the ceiling, making them unacceptable as isolation rooms. The room as a whole is acceptable to be considered a single isolation room, but short-walled cubicles will allow airflow and aerosols between compartments, and is not appropriate for both COVID and non-COVID patients. It is not our recommendation to utilize this room in this way. The town should confirm with the Department of Health whether this approach is acceptable. If it is not, a new plan for an isolation room that conforms to the State's guidelines must be made and executed prior to re-opening the building.

Room C203 has supply and return connections to an RTU, which likely recirculates air to other parts of the building. Filtering all returns from C203 to the RTU is recommended to mitigate viral

particles from reentering the supply airstream, as is the reduction of supply air and addition of an exhaust fan to depressurize the room.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Investigate OA damper position issues in relation to BAS set points and readings. Confirm the physical damper setting matches the BAS.
2. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
3. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
4. Replace any dirty or damaged filters in all RTUs and ERV. If possible, replace RTU RA filters with MERV 13 filters.
5. Building Code Concern: Instruct occupants not to obstruct supply or return grilles with equipment or supplies.
6. Ensure all RTUs serving occupied spaces are set to operate during occupied hours.
7. Install new supply and return air ductwork to workout room and Nurse's office for code-required ventilation. Connect to the nearest RTU.
8. Confirm with the Department of Health that the room arrangement selected as the isolation room is acceptable. Once the isolation room arrangement is confirmed, install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. A portable HEPA filter is recommended to clean the air within the room during and after occupation.
9. Set all exhaust fans serving occupied areas to run continuously during occupied hours. Repair exhaust fans as necessary.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Investigate and repair or replace faulty sensors.
2. Replace damaged diffusers in the Gym and Cafeteria.
3. Install returns in Library offices, Classrooms A104 and A105, and Business Manager Office.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each single-zone RTU system to determine the minimum outside air fraction required for each RTU.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: James Hillhouse High School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at James Hillhouse High School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 25, 2020 and remote building automation system (BAS) review on October 6, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Multiple indoor air handling units (AHU), packaged rooftop units (RTU), makeup air units, fan coil units (FCU), and exhaust fans (EF) serve the building, installed in approximately the year 2000. At 20 years old, these units are nearing the end of their useful life (typically 20 years) and should be considered for replacement. These units provide all of the mechanical ventilation for the school and the AHUs and RTUs are equipped with hot and chilled water coils. All equipment witnessed appeared to be in working condition; however, most filters were in need of replacement. It was noted that the filter doors on RTU-5 and RTU-6 no longer close properly. All observable filters were far beyond their useful life and in need of replacement. If possible, final filters in all AHUs and RTUs should be replaced with MERV 13 filters. MAU-4, which serves various offices, was not in operation at the time of our visit. The kitchen lacks makeup air to replace air exhausted by the central kitchen hood.

Inside the building, the filter within FCU serving classroom G-206 was installed incorrectly, allowing filter bypass. Also, any of the storage rooms lacked minimal ventilation, which is required by code. The Costume Storage Room (C109E) was noted as extremely musty and had no exhaust.

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In addition to mechanical ventilation via an AHU or RTU, most classrooms have operable windows and small adjustable louvers on the exterior wall that can provide the room with passive ventilation. Since the classrooms receive mechanical ventilation via an AHU or RTU, the louvers are unnecessary and increase heating and cooling costs due to air leakage. The 3rd floor women's bathroom appeared to be missing code-required exhaust. Room B108, a records storage room, does not have ventilation. The Wood Shop Office and Music Practice Room lack return grilles. The Music room diffusers were noted as dirty. Kitchen staff informed us that the air system for the kitchen was serviced and cleaned in August.

Building Automation System Review Findings

Based on the review of the building's BAS, it was determined that the DDC is simply but effectively featured, with the points needed for control. All unit damper positions are indicated. Trend logs have been set up for this building, and can be used to diagnose problems with the system. No space temperature concerns were noted during our review; however, reviewing the HVAC during on a mild weather day does not easily showcase problematic thermostats or issues with the building's heating or cooling system. That said, the air handling units appeared to be performing as expected, and the majority of the VAV boxes were in reasonable agreement with the DDC set points and airflow readings. The robust configuration of the AHU's and the CO_2 reporting should allow control of outside air supply and allow it to be increased if desired (within the capacity limits of the heating and cooling capabilities of the units and heating/cooling plant.

At the large equipment level, demand-controlled ventilation (DCV) should be implemented, so that the minimum OA damper positions are observed. In this manner, when CO_2 levels increase due to student and staff occupancy, the controls will introduce additional outside air to meet the CO_2 set point. With confidence in this system, the outside air ventilation into the school can be adjusted remotely. CO_2 sensors need to be calibrated and in some cases replaced. Some AHU and RTU return air (RA) CO_2 sensors report a level far below typical outside air conditions. These sensors do not perform well with age and they tend to drift to low readings, making them unreliable as a means of evaluating or controlling ventilation. Once the sensors are replaced and DCV can be used confidently, the CO_2 set point should be adjusted to 600 ppm to ensure maximum ventilation. Minimum OA damper positions should be set to 30% open to ensure ventilation during all occupied hours. The number of alarms noted were small in relation to the quantity of equipment incorporated into the BAS, however this should be revisited when the weather gets colder. Current alarms and deviations from set point problems should be addressed now.

Nurse's Suite

The School Health Clinic resides in Suite B107. Room B107I is designated a "sick room" for non-COVID patients. Room B107H is designated a "Well Room" for exams and vaccines. Room B107C, which has an outside wall, is designated the "Isolation Room". No dedicated toilet is

associated with this room. Room B107B may also become an isolation room, and does have a dedicated toilet. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment in both isolation rooms.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be taken:

1. Upgrade all AHU and RTU filters to MERV 13.
2. In the isolation rooms, install a HEPA-filtered negative air machine to the return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. An exhaust fan may be employed to exhaust air to the outdoors.
3. Troubleshoot MAU-4 and enable unit to run continuously to ventilate office areas.
4. Install exhaust in 3rd floor Women's bathroom.
5. Set all general exhaust fans to run constantly during occupied hours.
6. Set minimum OA airflow in each RTU and AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
7. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace filters in all classroom FCUs.
2. Clean Music Room diffusers.
3. Install ventilation in all storage rooms per code.
4. Repair doors on RTU-5 and -6 to prevent air loss.
5. Install return grilles in Wood Shop Office and Music Practice Room.
6. Install a makeup air unit for the Kitchen and interlock its controls with the existing exhaust system.

7. Install new louver seals in classrooms to prevent leaks and reduce heating and cooling costs.
8. Install new FCU damper position and freeze status points to allow interior demand controlled ventilation.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Repair/replace aging equipment.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: John C. Daniels School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the John C. Daniels School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 29, 2020 and remote building automation system (BAS) review on October 14, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Five indoor air handling units (AHU) serve the building, installed in 2005. These units supply all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. The filters and outdoor air (OA) damper in AHU-1 were inaccessible during the site visit. The other four AHUs all had clean MERV 8 filters that appeared to be replaced recently, although none of the filters were dated. The OA damper in AHU-2 was observed to be closed. The OA dampers in AHU-3, 4, and 5 were observed to be slightly open.

Most occupied rooms are equipped with both supply diffusers and return grilles to provide airflow to/from an AHU with the exception of the gym offices, which only have supply diffusers. Variable Air Volume (VAV) boxes control the airflow into each room and fine tune the temperature. Dirty supply diffusers or grilles were noted in the library and room 229. Damaged supply and return diffusers/grilles were noted in the gym.

Building Automation System Review Findings

Based on our review of the building's BAS, it is our opinion that the system has some deficiencies that must be addressed prior to re-opening the building to ensure sufficient outdoor air is being

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delivered to the rooms. The AHUs have demand-controlled ventilation (DCV) capabilities, but the system is in need of repair in order to confidently use the DCV. AHU-1 and 5 appear to have faulty CO_2 sensors with both reading 0 ppm. AHU-3 has a CO_2 set point of 1200 ppm. All points on the AHU-4 graphic read 0, indicating an issue with the unit's controller. AHU-5 shows a duct static pressure reading of 0.0, indicating a bad pressure transducer or plugged static tube. All AHUs show an OA damper position of 0% although the minimum set point is 15%. In order to ensure maximum OA ventilation throughout the building, it is recommended that all faulty sensors and controllers be investigated, replaced or repaired as necessary prior to re-opening the building and the CO_2 set point be adjusted to 600 ppm. The minimum OA damper position should be set to 30% to ensure constant ventilation during occupied hours even if the CO_2 concentration drops below the set point.

At the time of the review, the outdoor temperature was well above the boiler-enabling set point of 60°F. However, Boiler B-1 was enabled with a hot water supply temperature of 213°F, which resulted in an alarm status. (The bottom of the heating water loop near the boilers is under an amount of head pressure greater than atmospheric pressure, which makes a water temperature of 213°F possible.) Neither hot water pump was enabled, allowing water to stagnate near the boiler and overheat. This indicated that while the hot water pumps are obeying the temperature lockout setpoints, Boiler B-1 is not.

Only four of the building's exhaust fans are represented in the BAS, all of which appear to be enabled and working. There are other pages for the rest of the fans, but they would not load during the system review. All exhaust fans serving occupied areas should be set to run constantly during occupied hours.

Nurse's Suite

The school nurse's office is located within a health suite that includes a reception area, a cot area with three cots, each with a curtain, an office, three exam rooms, and a dedicated bathroom. At the time of the site visit, no isolation room had been identified. Once a room is identified to be converted into an isolation room, it is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Investigate all faulty sensors and repair/replace as necessary for proper BAS operation.
2. Investigate AHU-4 controller and repair/replace as necessary for proper BAS operation.

3. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
4. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
5. Ensure all exhaust fans are represented in the BAS. Set all exhaust fans serving occupied spaces to run constantly during occupied hours.
6. Upgrade AHU filters to MERV 13 if possible.
7. Identify an isolation room.
8. Once the isolation room is chosen, a HEPA-filtered negative air machine should be installed in the isolation room's return grille and the supply-side volume damper partially closed to ensure a negatively pressured environment within the isolation room. If a HEPA filter cannot be obtained, seal off supply and return grilles to create a passive isolation room appropriate for short occupation.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean all dirty or clogged diffusers and grilles.
2. Replace broken grilles/diffusers in gym.
3. Install returns in gym offices.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone AHU system to determine the minimum outside air fraction required for each AHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: John S. Martinez School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the John S. Martinez School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 27, 2020 and remote building automation system (BAS) review on October 22, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Fifteen (15) outdoor air handling units (AHU), and twenty (20) exhaust fans (EF) serve the building, installed in 2003. These air handling units provide most of the mechanical ventilation for the school and most are equipped with hot and chilled water coils. AHU-1 has DX cooling rather than chilled water, AHU-8 and 12 have DX cooling in addition to chilled water, and AHU-13 is not equipped with any cooling coils. During the site visit, all AHUs serving occupied spaces were running. All AHUs have MERV 8 filters installed. The filters were dated September 2019, but were noted to appear clean and undamaged. AHU-3, 5, 6, 9, 10, 11, 12, and 15 were observed to have closed OA dampers, and the rest of the AHUs were observed to have open OA dampers. Most occupied rooms are equipped with both supply and return diffusers/grilles. Office 210 is the only occupied room without a supply or a return diffuser. Diffusers and grilles in rooms 189, 190, 190A, and the gym were noted to be dirty or clogged. The diffusers and associated ductwork should be cleaned before re-opening the building to ensure proper airflow within the spaces.

Building Automation System Review Findings

Based on the remote review of the BAS, some AHUs require attention prior to opening the building. The AHU-1 and 7 graphics show all zero values in the BAS, indicating potential control

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communication issues. AHU-2 and 4 were not running at the time of the review and their supply fan indicated a variable frequency drive (VFD) error. In addition to the VFD errors, there are a number of active alarms within the system. All active alarms should be investigated and corrected prior to re-opening. Some AHUs graphics reported inconsistent damper positions vs their reported airflows. The flow sensors will need to be calibrated.

Demand-controlled ventilation (DCV) is available on most AHUs, but has been disabled. DCV should be enabled and set to 600 ppm to ensure OA is being provided to the building. The minimum OA damper positions should be set to 30% to ensure constant ventilation during occupied hours, even if the CO_2 concentration drops below the set point.

During the BAS review, some of the exhaust fans did not appear within the system. Of those that were visible, EF-6, 7, 8, 13, and 14 were commanded on, but not running. This should be investigated and all general and toilet room exhaust fans should be set to run constantly during occupied hours.

Nurse's Suite

The school's health suite includes a reception area, the nurse's office, two other offices, three exam rooms, a dedicated bathroom, and a lab. Within the health suite, office 118 has been identified as an isolation room and has supply and return connections to AHU-8 as well as operable windows. AHU-8 recirculates air throughout the administration area. It is recommended that a HEPA-filtered negative air machine be installed in the room's return duct and the supply be sealed off to ensure a negatively pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be taken:

1. Replace all AHU filters and upgrade to MERV 13 where possible.
2. Install a HEPA-filtered negative air machine to the isolation room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air

percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

4. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
5. Troubleshoot or replace AHU-1 and 7 controllers.
6. Troubleshoot AHU-2 and 4 supply fans and VFD errors.
7. Troubleshoot and correct all alarms and VFD faults.
8. Flow sensors and damper positions should be calibrated to ensure that values reported in the BAS accurately represent airflows.
9. Investigate why EF-6, 7, 8, 13, and 14 do not run when enabled via the BAS.
10. Set all exhaust fans serving occupied spaces to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean all dirty or clogged diffusers and grilles.
2. Install supply and return diffusers/grilles in office 210.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

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David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
- Center for Disease Control, Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation, September 22, 2020
- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Kathrine Brennan School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Katherine Brennan School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 25, 2020 and remote building automation system (BAS) review on October 11, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Eight rooftop units (RTU) and seventeen exhaust fans serve the building. All of these units were installed when the building was renovated in 2001. These units supply all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. At 19 years old, the units are nearing the end of their useful lives (typically 20 years). Upon inspection, it was clear that all of the filters in the RTUs are due to be replaced. The filters were dated to have last been replaced in 2016. These filters were visibly dirty and in some cases, damaged. All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an RTU. Dirty supply diffusers were noted in the cafeteria. Dirty return/exhaust grilles were noted in the Cafeteria, the Boys' Bathroom (Room 53), and the Gym.

Building Automation System Review Findings

During the review of the building's BAS, all RTUs were running, except for the supply fans associated with AC-3 and AC-5, which were in alarm status. All RTU mixed air dampers were set to 50% open with the exception of AC-1, which was set to 10%. None of the units were set to operate in economizer mode. AC-4 return air CO_2 sensor appeared abnormally low, indicating the

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need for replacement. Most of the mixed air temperatures do not meet set point. The temperature sensor in the Girls' Room 91 is malfunctioning. Global points such as the outdoor air temperature and outdoor air CO_2 sensor are functional.
Exhaust fans EF-1, 2, 3, 6, 7, and 12 were turned off and EF-4 and 5 had active alarms. All other exhaust fans were running. All Exhaust fans serving occupied areas should be set to run constantly during occupied hours.

Nurse's Suite

The school nurse's office is located within a health suite that includes a reception area, offices for the school psychologist, speech therapist, and social worker, a dental lab, a dental operatory, storage rooms, and a bathroom. The Dental Operatory is being converted into the school's isolation room. This room is equipped with supply and return grilles as well as operable windows. The room is conditioned and ventilated by AC-6, which also serves the rest of the Health Suite as well as the Custodian and PE Offices across the hall.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace filters in all RTUs. If possible, upgrade to MERV 13.
2. Investigate alarms associated with AC-3 & AC-5 supply fans.
3. Set the RTU outdoor air dampers to allow the maximum volume of outdoor air to enter the building. Re-visit sequence of operation and adjust mixed air set points to maximize RTU economizer operation during the shoulder seasons and incorporate purge mode.
4. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
6. Investigate why EF-1, 2, 3, 6, 7, 12 are off. Set all exhaust fans serving occupied areas to run constantly during occupied hours.
7. Investigate alarms associated with EF-4 and 5.
8. Install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a

HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean dirty supply diffusers and return grilles in the Cafeteria, Boys' Bathroom (Room 53), and the Gym.
2. Replace malfunctioning AC-4 RA CO2 sensor.
3. Replace malfunctioning Rm 91 temperature sensor.

As part of a future renovation, it is recommended to incorporate the following:

1. Replace aging RTUs.
2. Additional space CO2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta

David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
- Center for Disease Control, Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation, September 22, 2020
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- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: King/Robinson Magnet School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the King/Robinson Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 15, 2020 and remote building automation system (BAS) review on October 17, 2020, it is our opinion that the building's ventilation systems have substantial deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Eight indoor air handling units (AHU), and 16 exhaust fans (EF) serve the building, installed in 2003. These units provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. At the time of our visit, all AHUs utilized MERV 11 filters, dated January 2015. All filters are well past their lifespan and should be replaced immediately. Pre-filters within AHU-6 were missing. Filters and outdoor air (OA) dampers within AHU-1, 2, and 4 were not accessible during the site. The OA damper on AHU-6 appeared to be closed. AHU-3, -5, -7 and -8 were noted to have open OA dampers. Most occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU. Conference Room 332 and Office 240 do not have return or exhaust grilles.

Building Automation System Review Findings

Based on the remote review of the BAS system, some of the AHU controls require attention prior to reopening the building. At the time of review, the AHU-1 return air temperature was not available and the mixed air temperature was much lower than the outdoor air temperature, indicating possible sensor malfunction. The AHU-4 heating coil temperature readings were not available, also indicating possible sensor malfunction. The OA dampers in AHU-6 and -8 were each partially open, but their return fans were off.

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The majority of the units' mixed air temperature readings were much higher than their respective set points. AHU sequences of operations and set points should be reviewed.

Return air CO_2 sensors in AHU-2 and 4 appear to be malfunctioning based on abnormally high readings while the building is unoccupied. Half of the room CO_2 readings were outside of the typical range while un-occupied, an indication of sensor malfunction. Demand controlled ventilation (DCV) is possible through the return air CO_2 sensors in Each AHU, and should be enabled. When the system is running on DCV, the set points should be lowered to 600 ppm to maximize the OA entering the building.

The flow rate for all VAVs in the building was shown as "N/A" in the BAS. These units should be checked to make sure they are operational. BAS connectivity should also be checked.

All exhaust fans appeared operational except TEF-9, which was turned off. All general and toilet room exhaust fans should be running while the building is in an occupied mode.

Nurse's Suite

The school nurse's area includes a reception area, four offices, two exam rooms, a cot area and a dedicated bathroom. No isolation room was identified during the site visit, and are mandated by the State of Connecticut. Once an isolation room is identified, a HEPA-filtered negative air machine should be installed in the return ductwork, and the Isolation Room's supply air flow should also be restricted to create a negative pressure within the space.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Upgrade old filters in all AHUs to MERV 13.
2. Identify an isolation room and install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Set the AHU outdoor air dampers to allow the maximum volume of outdoor air to enter the building. After the BAS adjustment, physically inspect damper position for each unit.
4. Investigate physical damper position, fan status, and sensors to diagnose malfunction within all air handling units.
5. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air

percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.

6. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
7. Troubleshoot or replace room CO_2 sensors with readings less than 300ppm or greater than 1000ppm.
8. Set all exhaust fans serving occupied areas to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace damaged grilles/diffusers.
2. Install return grilles in Conference Room 332 and Office 240.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone AHU system to determine the minimum outside air fraction required for each AHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:

Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
- Center for Disease Control, Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation, September 22, 2020
- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Lincoln-Bassett School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Lincoln-Bassett School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, sand provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 15, 2020 and remote building automation system (BAS) review on October 25, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

At the time of writing this report, no mechanical drawings of the building have been made available to us.

Field Observations

Seven packaged rooftop units (RTU) and three indoor air handling units (AHU) serve the building, installed in 2000. The units are in functional condition. However, they are considered approaching the end of their useful lives and should be replaced shortly. These units provide all of the mechanical ventilation for the school and are equipped with hot water coils and DX cooling. At the time of the site visit, RTU-3 was not running[EL1].

The filters and outdoor air (OA) dampers in RTU-1 and 2 were inaccessible during the site visit. The accessible AHUs and RTUs all had MERV 8 filters installed. These filters were dated August 2020 and appeared to be clean and undamaged. The position of the OA dampers within the RTUs were not readily visible during the site visit. All of the AHU OA dampers were observed closed.

Most of the building's occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU or RTU. The kitchen office has a supply connection, but no return or exhaust. Return grilles in the gym were noted to be in need of cleaning.

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Building Automation System Review Findings

Based on our remote review of the BAS, the majority of the air handling units require attention. AHU-1 outdoor air (OA) damper is set at 10% open. AHU-2 and AHU-3 OA dampers are set at minimum 20% open; however, they are fully closed upon examination in the field. We recommend checking that the set points and condition of the damper sensors/ linkages conform to those reported in the BAS.

OA damper positions for the RTUs is not available on the BAS. OA damper positions should be maximized during the shoulder season. The minimum OA damper position should be set to 30% to ensure constant ventilation during occupied hours regardless of CO2 status.

Return air (RA) fans for AHU-2 & 3 are enabled but off. AHU-2 OA is closed and is running 100% RA; however, the freeze alarm is on. Demand control ventilation is possible and recommended for the AHUs, as CO_2 sensors are in the return air duct, and currently set between 800 and 1000 ppm. Lowering these set points to 600 ppm is recommended to maximize outdoor air intake during occupied hours.

EF-1, 2, 4, 5, 6, 7, 13, 14, and 15 were off during the system review. It is recommended that general and toilet room exhaust fans be set to run constantly while the building is occupied. The hydronic heating system was disabled during the system review, and should be inspected to determine if it was manually disabled or if set points need to be evaluated and sensors need to be re-calibrated.

Nurse's Suite

The school nurse's office is located within a health suite that includes a reception area, two offices, two exam rooms, and two dedicated bathrooms. The SBHC office is being converted into the school's isolation room. This room has supply and return connections to an AHU or RTU, which is likely to recirculate air throughout other areas within building. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. If possible, upgrade filters in all RTUs and AHUs to MERV 13.
2. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Investigate RTU-3 operation and ensure that the unit is functional.
4. Check freeze-alarm sensor on AHU-2.

5. Investigate set points and OA damper controls to diagnose issues with OA set points. Correct issues once properly diagnosed.
6. Set minimum OA airflow in each RTU/AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
7. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
8. Investigate return fans in AHU-2 and 3, which were enabled but off during the BAS review.
9. Investigate EF-1, 2, 4, 5, 6, 7, 13, 14, and 15, which were all not running during the BAS review.
10. Set all exhaust fans serving occupied areas to run continuously during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean dirty grilles/diffusers in the gymnasium.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU or AHU system to determine the minimum outside air fraction required for each RTU and AHU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Mauro-Sheridan Magnet School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Mauro-Sheridan Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 20, 2020 and remote building automation system (BAS) review on October 15, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Eight air handling units (AHU) equipped with heat-recovery, two makeup air units (MAU), seventy nine shut-off variable air valve (VAV) boxes with hydronic reheat, and twenty one exhaust fans (EF) serve the building. These units provide all of the building's outdoor air. Most AHUs are equipped with supply and exhaust fans, energy recovery wheels with bypass dampers, demand controlled ventilation, static pressure controlled variable speed fans, and room static pressure control. Variable air volume (VAV) boxes with hot water reheat coils fine tune AHU air temperature and flow throughout the building.

At the time of our site visit, all of the air handling units were running. All AHUs have MERV 8 pre-filters and MERV 11 final filters that are dirty and are in need of replacement. It was noted that some of the filters in AHU-1 were installed backwards, while other filters on the rack were installed in the correct direction. The final filters should be upgraded to MERV 13. Outdoor air (OA) dampers were observable on some AHUs ranging from fully open to fully closed. AHU-2, 3, 4, 6, and 7 were noted to have fully closed OA dampers. AHU OA damper minimum set points should be incorporated to ensure ventilation during occupied modes. All occupied rooms were noted to have both supply and return connections to an AHU.

EF-1, 8, 9, 10, 11 14, 15, 16 and 18 were not running during the site visit. At a minimum, EF-1 and 15 should be running during occupied hours as they are general purpose exhaust fans. MAU-1 and

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its associated EF, KEF-1, were not running during the site visit. This is only a problem if they do not run while the kitchen is in use. The interior components of MAU-1 were noted to be in need of cleaning and the filters in need of replacement. MAU-2 serves as boiler combustion air and was not running at the time of our visit.

Building Automation System Review Findings

Based on our review of the BAS system, multiple inconsistencies and failures relating to AHUs should be investigated and corrected in order for the VAV boxes to function properly and ensure proper OA introduction. AHU-1, -2, -3, -4, and -7 were found to have an abnormally low return air (RA) CO_2 readings, which indicates sensor failure. AHU-1, -4, -5, and -8 reported extremely high and abnormal RA humidity levels indicating a need for inspection and possible replacement. EF-4, 5, 6, and 18 were found to be in alarm status as they were commanded on, but not running. All exhaust fans need inspection to verify operation.

MAU-2, which provides combustion air to the boilers, was found to be pre-heating the combustion air when there did not appear to be a need. This unit was running despite the system showing that it was off, indicating an issue with the unit's proof point. The heating system seems to be running against what is called for by the BAS, as boilers B-2 and B-3 were supplying hot water to the system while the outside temperature was over the permissive temperature for activating the heating system. The OA CO_2 sensor appears to be inaccurate, displaying a 2.0 ppm OA CO_2 reading. Toilet Room 142 reports a space temperature of 0.0°F, indicating a sensor issue.

Nurse's Suite

The Nurse's Suite consists of a waiting area, three exam rooms, and two offices. The nurse's office 127D has been identified as the isolation room. This isolation room is equipped with supply and return connections to AHU-6 as well as operable windows. The AHU-6 serving the Nurse's Office recirculates air throughout other areas within the building. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode.
2. Set exhaust fans serving occupied areas to run constantly during occupied hours.
3. Before occupancy, review the operational sequence of all exhaust fans and make sure they operate as dictated by occupancy status (time schedule, not occupancy sensor). Confirm all exhaust fans function properly, as the BAS review revealed multiple run command errors.

4. Prior to re-opening the building, AHUs should be set to maximize OA capacity as weather and CO_2 set points allow.
5. Investigate and correct equipment sensor issues, including RH and CO2 sensors.
6. Investigate and correct MAU-2 settings and controls.
7. Replace AHU final filters with MERV 13 or better.
8. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
9. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
10. Install a HEPA-filtered negative air machine to the isolation rooms' plenum return. Reduce supply air to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply diffuser and return grille (located above the ceiling) to create a passive isolation room appropriate for short-duration occupancy.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Investigate and correct Toilet Room 142 temperature sensor.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 in the building.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:

Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
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- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
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- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
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- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Metropolitan Business Academy - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Metropolitan Business Academy. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 15, 2020 and remote building automation system (BAS) review on October 12, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Eight packaged rooftop units (RTU), one heat recovery unit (HRU), one make-up air unit (MAU) and ten exhaust fans (EF) serve the building, installed in 2008. These units provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. All eight RTUs have new MERV 13 filters installed in October 2020. RTUs 3 through 7, MAU-1, and EFs 1 through 4 were not running during the site visit. At a minimum, RTU-3, RTU-4, and EF-3 should be scheduled to run during all occupied hours, as they serve classrooms and toilets, respectively. Mechanical drawings indicate that bipolar ionization is currently installed in each RTU to treat diesel fumes within outdoor air intake. This system treats the total supply air into the building. All RTUs were observed to have open OA dampers during the site visit. Filters and dampers in the HRU and MAU were not accessible at the time of the visit.

All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an RTU. Dirty return grilles were noted in the media center and second floor computer lab.

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Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Building Automation System Review Findings

Based on the remote review of the BAS, the system needs some adjustments prior to opening the building for occupation. At the time of review, there were bipolar ionization gauge (BPIG) alarms associated with RTU-2, 3, 5, and 8 and a filter alarm for RTU-5. All alarms should be investigated and resolved prior to the building's re-opening. The system does not have return air CO_2 sensors, which makes demand-controlled ventilation not an option. The OA dampers were all set to be 100% open, which aligns with observations made during the site visit. All exhaust fans were noted as operational based on the BAS system. The fans should be checked to make sure they are all running when commanded to. It is recommended that general exhaust fans be set to run continuously while the building is occupied.

Nurse's Suite

The school nurse's suite (Suite 112) consists of a waiting area, exam room, resting area, dedicated toilet and health office. Room 103, which currently serves as the school store, has been identified as an isolation room and is located near the entrance, away from the Nurse's suite. This room is equipped with supply and return connections to RTU-2, which also recirculates air throughout the building's administrative areas. It is recommended that a HEPA-filtered negative air machine be installed in the room's return duct and the supply be sealed off to ensure a negatively-pressured environment.

Testing and Balancing

On November 25, 2020, Wing's Testing and Balancing, a sub-consultant of F&O, evaluated airflow and odor concerns in the science and prep rooms on the 2nd through 4th floors. Wing's evaluated RTU-3 and EF-5, which are dedicated to the stacked science areas. They found that the belts on EF-5, which serves the prep rooms, was broken. The condition was reported immediately to facilities for repair. No replacement belts were found on site. A controls technician was not on site during the evaluation. Although it had been reported that filters were in the process of being changed, the filters in RTU-3 were dirty and the return fan motor belt was found to be loose. This may explain the reduced performance of RTU-3, which was measured at 80% of design total airflow.

In addition to rooftop equipment, grille and diffuser airflows were measured in each science classroom, as well as VAV performance in response to lab hood exhaust. Airflows in all science rooms with the lab hoods off operated above design values. A controls technician was unavailable during this testing, so it was not possible to force the VAV in the 4th floor prep room to fully open to test the maximum airflow.

The Wings' findings and recommendations can be found as *Appendix B*.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be taken:

1. Install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. A portable HEPA filter is recommended to clean the air within the room during and after occupation.
2. Investigate active alarms associated with RTU-2, 3, 5, and 8.
3. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
4. Schedule RTU-2 and 3 to run during all occupied hours.
5. Confirm all exhaust fans run when commanded by BAS. Set all exhaust fans serving occupied areas to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Clean all dirty/clogged diffusers and grilles.

As part of a future renovation, it is recommended to incorporate the following:

1. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
2. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

WING'S TESTING & BALANCING CO., INC.

APPENDIX B

New Haven Public Schools
MBA Science Rooms
Air Flow Testing

* * * *

Fuss & O'Neill Inc.
Attn: Jennifer Turber, PE
146 Hartford Road
Manchester, CT 06040

November 30, 2020

94 North Branford Road • Suite One • Branford, CT 06405
(203) 481-4988 • Fax (203) 488-5634 • wings@wingstesting.com
SM-1 License #6803
www.wingstesting.com

WING'S TESTING & BALANCING CO., INC.

Fuss & O'Neill Inc.
Attn: Jennifer Turber, PE
146 Hartford Road
Manchester, CT 06040

November 30, 2020

Re: New Haven Public Schools – MBA – Science Rooms Air Flow Testing

Dear Jennifer:

The air flow testing of the above referenced location has been completed and noted on our attached data sheets.

Findings:

- Exhaust Fan EF-5 which serves Prep Room on Second, Third, and Fourth floors was found with broken belts.
    - We could not find any replacement belts onsite.
- A control technician was not present on site during our testing
    - We could not see flow on the BMS or force the boxes to different settings.
- We tested the supply boxes in rooms with chemical fume hoods when the hoods were both on and off.
    - We noted that the flow changed at the VAV boxes when the hoods were indexed on and off.
- Note that the 4th floor lab has no fume hood. (was a change in the drawings)
- During our testing, RTU-3 was operating at 100% outside air.
    - The filters were noted to be dirty
    - The return fan motor belt was a little loose.
- We calculated air changes per hour in each room for record.

We recommend the following:

- Install a new belt on EF-5
- Install new filters on RTU-3
- Tighten RTU-3 return fan belt
- Re-test flow with control contractor support to document BMS settings vs actual.

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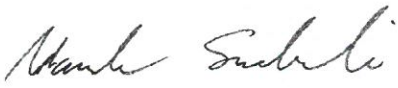
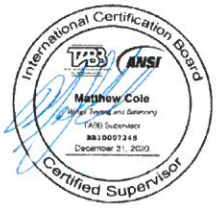
(203) 481-4988 • Fax (203) 488-5634 • wings@wingstesting.com
SM-1 License #6803
www.wingstesting.com

The following pages are your record of current operating conditions. If you have any questions, or if we can be of further service, please do not hesitate to call.

Very truly yours,

Wing's Testing & Balancing Co., Inc.
ICB Certified Contractor for:
TABB—Commissioning—Fire/Life Safety L1&L2—Sound & Vibration





Marek Sadowski
Certified TABB Technician #BB1083468T
CT SM-2 License #7078
MA SM-2 4508
HVAC Fire Life Safety Level 1 Tech FLS11083468T
EPA Universal Technician AA2804U0003

SUPPLY FAN REPORT

PROJECT: New Haven Public Schools - MBA Science Building	**DATE:** 11/25/20
SCHOOL: MBA	**TECH:** MS

SYSTEM DATA

FAN NUMBER	RTU-3					
MANUFACTURER	Trane					
MODEL OR SIZE	TSCB006UF					
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	3500	2817				
RETURN AIR	ND	---				
OUTSIDE AIR	ND	2817 (1)				
O.A.D.MIN POS	(1)					
FILTERS- QTY/ SIZE	4-16" x 20" x 2"					
FILTER CONDITION	Dirty					
BELTS - QTY / SIZE SUP/RET	1-Bx45/1-A43					
BELT CONDITION	Good, little loose					
COIL CONDITION	Good					

SYSTEM DATA

FAN NUMBER						
MANUFACTURER						
MODEL OR SIZE						
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM						
RETURN AIR						
OUTSIDE AIR						
O.A.D.MIN POS						
FILTERS- QTY/ SIZE						
FILTER CONDITION						
BELTS - QTY / SIZE						
BELT CONDITION						
COIL CONDITION						

SYSTEM DATA

FAN NUMBER						
MANUFACTURER						
MODEL OR SIZE						
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM						
RETURN AIR						
OUTSIDE AIR						
O.A.D.MIN POS						
FILTERS- QTY/ SIZE						
FILTER CONDITION						
BELTS - QTY / SIZE						
BELT CONDITION						
COIL CONDITION						

REMARKS

(1) no access to BMS - runs on 100% O.A. during testing
NA-Not Available
ND-No Design DD-Direct Drive

VELOCITY PRESSURE READINGS

PROJECT: New Haven Public Schools - MBA Science Building | **DATE:** 11/25/20

AREA SERVED: Sceince Labs 2nd 3rd, & 4th Floors | **TECH:** MS

TRAVERSE LOCATIONS	DUCT SIZE "	AREA SQ.FT.	DESIGN FPM	DESIGN CFM	CENTERLINE STATIC PRES."	TEST FPM	TEST CFM	NOTES
EF-5								
Total	12" x 10"	0.83	795	660	---	---	---	(1)
RTU-3								
Total Inlet #1	17 1/2"x 14 1/4"	1.73	---	---	w/velgrid	613	1061	
Total Inlet #2	17 1/2"x 14 1/4"	1.73	---	---	w/velgrid	624	1080	
			Total	3500			2141	(2)

REMARKS

(1) Fan has broken belt
(2) TCL - Boxes under auto control during testing

AIR DEVICE / BOX REPORT

PROJECT: New Haven Public Schools - MBA Science Building | **DATE:** 11/25/20

SYSTEM/AREA SERV: RTU-3/ 2nd, 3rd, & 4th Floors | **TECH:** MS

				DESIGN			TEST 1		FINAL			DP		
LOCATION	NO.	SIZE	AK	MIN	FPM	CFM	FPM	CFM	MIN	FPM	CFM	MIN	MAX	NOTES
2nd Floor														
VAV-F		**12"Ø**					**Hood Off**		**Hood On**					
Chemistry Lab 208A	1	2408	FH	---	---	150	---	137	---	---	173			
Chemistry Lab 208A	2	2408	FH	---	---	200	---	164	---	---	202			
Chemistry Lab 208A	3	2408	FH	---	---	200	---	182	---	---	233			
Chemistry Lab 208A	4	2406	FH	---	---	100	---	81	---	---	103			
Chemistry Lab 208A	5	2408	FH	---	---	200	---	161	---	---	218			
Chemistry Lab 208A	6	2408	FH	---	---	150	---	136	---	---	174			
Chem Prep 208B	7	2406	FH	---	---	100	---	90	---	---	114			
				120/800		1100		951			1219			(1)
Return/Lab	R1	24"x24"	FH	---	---	880	---	678	---	---	678			
3rd Floor														
VAV-F		**12"Ø**												
Biology Lab 308A	1	2408	FH	---	---	150	---	43	---	---	144			
Biology Lab 308A	2	2408	FH	---	---	200	---	57	---	---	204			
Biology Lab 308A	3	2408	FH	---	---	200	---	66	---	---	205			
Biology Lab 308A	4	2406	FH	---	---	100	---	33	---	---	100			
Biology Lab 308A	5	2408	FH	---	---	200	---	62	---	---	209			
Biology Lab 308A	6	2408	FH	---	---	150	---	51	---	---	177			
Chem Prep 308B	7	2406	FH	---	---	100	---	41	---	---	104			
						1100		353			1144			(1)
Return/Lab	R1	24"x24"	FH	---	---	880	---	723	---	---	723			
4th Floor														
VAV-F		**12"Ø**												
Physics Lab 408A	1	2408	FH	---	---	200	---	75	---	---				
Physics Lab 408A	2	2408	FH	---	---	200	---	78	---	---				
Physics Lab 408A	3	2408	FH	---	---	200	---	64	---	---				
Physics Lab 408A	4	2408	FH	---	---	200	---	81	---	---				
Physics Lab 408A	5	2408	FH	---	---	200	---	68	---	---				
Physics Lab 408A	6	2408	FH	---	---	200	---	58	---	---				
Physics Prep 408B	7	2406	FH	---	---	100	---	30	---	---				
						1300		454						
Return/Lab	R1	24"x24"	FH	---	---	1080	---	742	---	---	742			(1)

REMARKS

Note: During testing VAV boxes under auto control, no access to BMS

(1) Min flow 120 CFM when fume hood off, 800 CFM when fume hood on.

AIR DEVICE REPORT

PROJECT: New Haven Public Schools - MBA Science Building | **DATE:** 11/25/20

SYSTEM / AREA: EF-5/ 2nd, 3rd, & 4th Floors Prep Labs | **TECH:** MS

LOCATION	NO.	SIZE	A K	DESIGN		TEST		FINAL		NOTES
				FPM	CFM	FPM	CFM	FPM	CFM	
4th Fl Prep Rm 408B	E1	10" x 10"		---	220	---	---			
3rd Fl Prep Rm 308B	E2	10" x 10"		---	220	---	---			(1)
2nd Fl Prep Rm 208B	E3	10" x 10"		---	220	---	---			
					660					(2)

REMARKS

(1) Grille blocked by refrigerator
(2) Fan has broken belt

AIR EXCHANGE RATES

PROJECT: New Haven Public Schools - MBA Science Building | **DATE:** 11/25/20

SYSTEM/AREA SERV: RTU-3 Science Labs 2nd, 3rd, & 4th Floors | **TECH:** MS

LOCATION	SUP EXH	ROOM FT 3	DESIGN CFM	CODE ACH	REQ'D RM PRESS.	TEST CONDITIONS			PASS FAIL	NOTES
						CFM	ACH	RM. PRESS.		
2nd Fl Lab 208	SUP	13865	---	---	---	1105	4.5	---	---	
Prep Rm 208A	SUP	1915	---	---	---	114	3.6	---	---	
3rd Fl Lab 308	SUP	13865	---	---	---	1040	4.5	---	---	
Prep Rm 308A	SUP	1915	---	---	---	104	3.3	---	---	
4th Fl Lab 408	EXH	13865	---	---	---	742	3.2	---	---	(1)
Prep Rm 408A	SUP	1915	---	---	---	30	1	---	---	(1)

REMARKS

Note: Air changes per hour tested for record only
(1) VAV boxes under control couldn't force box to max design flow

INSTALL DUCT TIGHT TO TOP OF OPENING

61x25 UP TO RTU-5

OUTLINE OF HVAC UNIT ABOVE

DOUBLE WALL SPIRAL DUCTWORK ROUTE THROUGH OPENING IN BEAMS

DUCTLESS SPLIT UNIT AC-1
PROVIDE ALARM TO BMS ON FAILURE.

18" LAB FUME HOOD EXHAUST DUCT UP (SS316)

12"ø SS.316 FUME HOOD EXHAUST

12x6 EA DUCT UP

3"CHILLED WATER SUPPLY & RETURN
2-1/2"HOT WATER SUPPLY & RETURN

RTU-3 SA/RA 16X12 UP

RTU-2 SA 24x18 UP/DN
RTU-2 RA 20x18 UP/DN

10x10 TOILET EXHAUST DUCT UP/DN

RTU-1 SA 20X20 UP

2ND & 3RD CORRIDORS DUCT. 20x8 UP TO 20x5 AROUND BEAM

1"HWS&R

RTU-2 SA/RA 24x12 UP

KITCHEN MAKE-UP DUCT

2ND FLOOR RA DUCTS 20x8 UP SEE DETAIL 2/M401

STUDENT CENTER BELOW

2ND FL

NORTH

2 LEVEL 3 PARTIAL PLAN
1/4" = 1'-0"

3/4" HWS UP TO FTR (TYP.)
3" CHWS&R, 2-1/2" HWS&R
RTU-2 SA 24x18 UP/DN
RTU-2 RA 20x18 UP/DN
RTU-1 SA 24x24 UP
RTU-1 SA 20x20 DN

12" SS316 FUME HOOD EXHAUST
12x8 EA DUCT UP

2ND & 3RD FL CORRIDORS RA DUCT, 20x8 DN TO 20x5 AROUND BEAM

3RD FLOOR RA DUCTS
2ND FLOOR RA DUCTS 20x5 AROUND THE BEAM

RTU-3 20x18 SA/RA UP
RTU-3 16x12 SA/RA DN

ATRIUM

10x10 TOILET EXHAUST DUCT UP/DN

3RD floor

18" LAB FUME HOOD EXHAUST DUCT DN (SS316)

12" SS316 FUME HOOD EXHAUST
22x20 UP TO RTU-3 SA CONNECTION

1-1/2" CHWS&R
1"HWS&R

22x20 UP TO RTU-3 RA CONNECTION

3" CHWS&R
2-1/2" HWS&R

RTU-3 20x18 SA/RA DN

RTU-2 24x18 SA DN
RTU-2 20x18 RA DN

10x10 TOILET EXHAUST UP/DN

RTU-1 24x24 SA DN

ER-A 220

12x10 EA DUCT DN TO 12x8

12x10 EA DUCT UP TO EF-5

18"ø FUME HOOD EXHAUST UP TO EF-2

26x26 UP TO MAU-1

RL&RS UP/DN ACC-1,2,3 UNITS

30x20 DN IN WALL

CUH B

3/4" HWS&R

FTR-A 5 LF

FTR-C 16 LF

FTR-C 24 LF

FTR-A 19 LF

FTR-A 19 LF

CD-A 200 (TYP. 6)

RR-A 1080

CD-A 180 (TYP. 4)

2-1/2" CHWS&R
2" HWS&R

3/4" HWS&R

CD-A 180 (TYP. 4)

10x6 (TYP. FOR 4)

PHYSICS PREP 414A

STAIR 2 ST2

CD-A 100

16x10

10x10

18x12

VAV-F 1300

22x20

20x16

24x18

20x18

1-1/2" HWS&R

10x8

PHYSICS CLAB 414A

10x6

10x10

CLASSROOM 412

10x6

10x6

VAV-D 720

16x10

34x16 SA

VAV-D 720

B-8 B401

CLASSROOM 410

16x10

10x10

36x14 RA

12x8

36x22

LECTURE HALL PASSAGE 418A

30x18

ENEC 416

8x4

8x6

8x4

26x26

CD-A 75

CD-A 60

6x6

ELEV

20x20 LOCKER ROOM/TOILETS MAKE-UP/ EXHAUST DUCTS DN

CD-A 200 (TYP. 2)

24x24 UP TO RTU-2 RA CONNECTION

CORRIDOR 405

VAV-B 300

RR-A 720

CD-A 75

8x6

10x8

RR-A 275

VAV-B 300

10x8

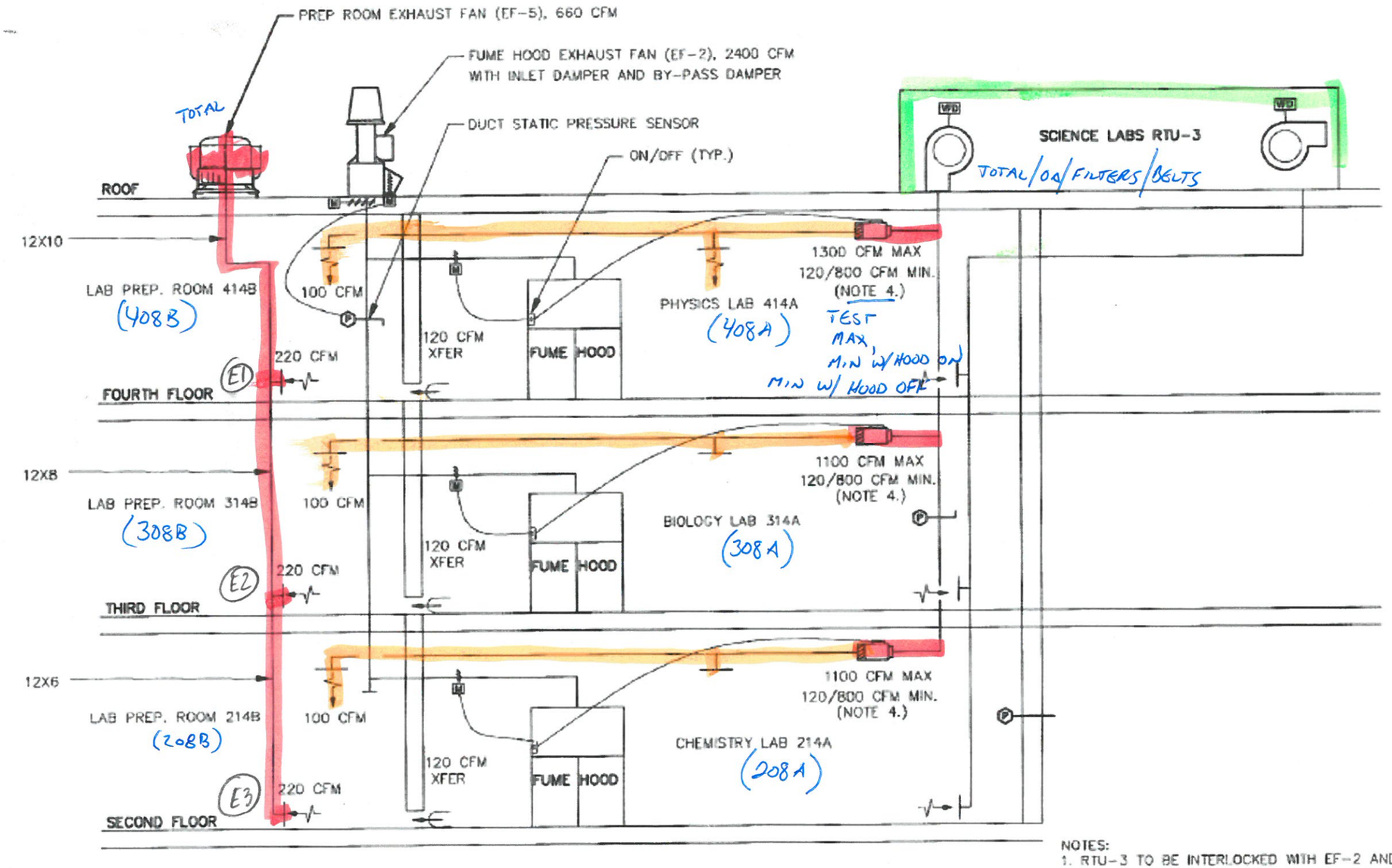
CD-A 75

24x10 SA

ER- 28x30 SMOKE EXHAUST DUCTS UP

A-A

4TH FLOOR

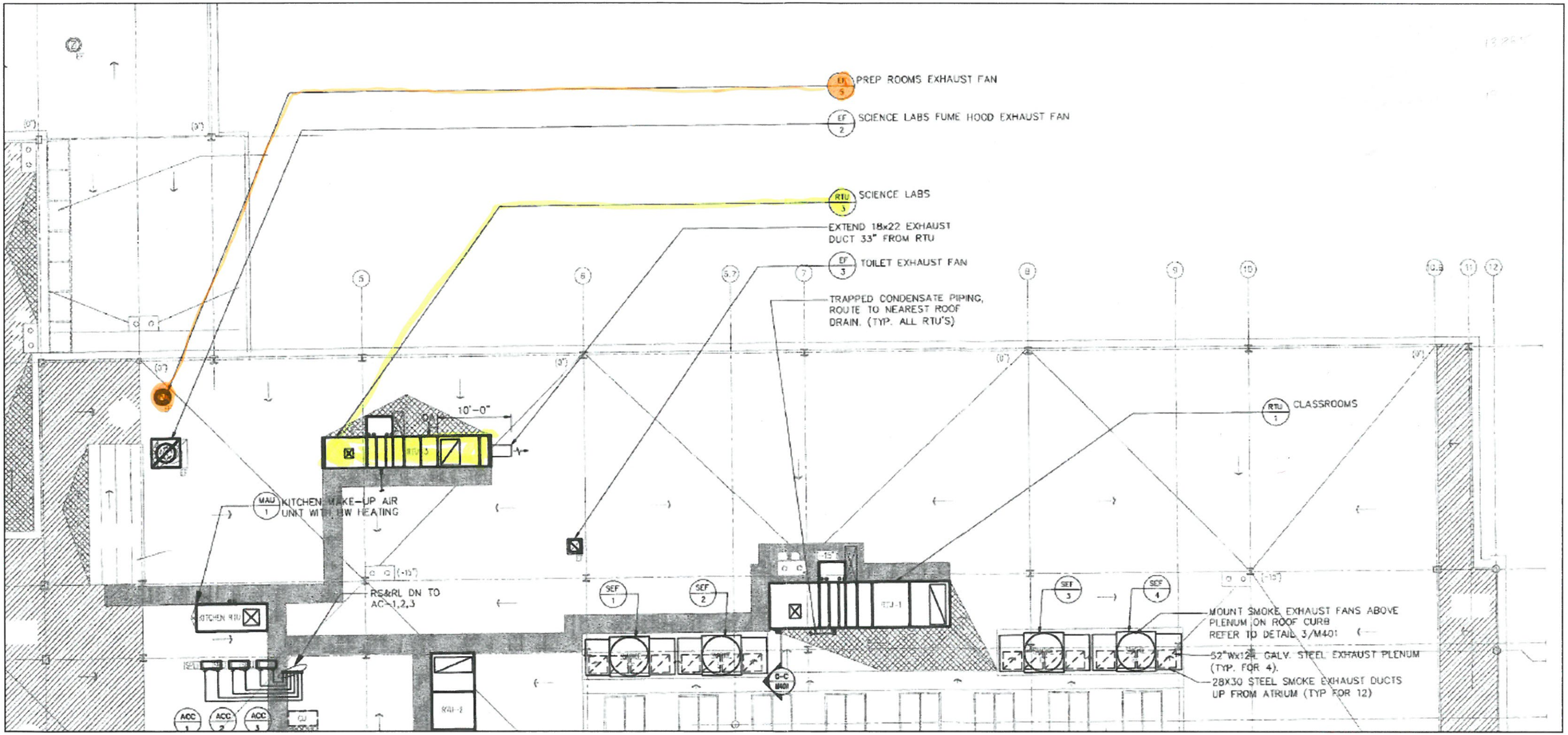


PREP ROOM EXHAUST FAN EF-5 SHALL RUN 24HRS/DAY.

NOTES:
1. RTU-3 TO BE INTERLOCKED WITH EF-2 AND EF-5.
2. FUME HOODS SHALL BE HAVE ON/OFF CONTROL INERLOCKED WITH MOTORIZED DUCT DAMPER.
3. FUME HOOD EXHAUST FAN EF-2 BY-PASS DAMPER SHALL MODULATE TO MAINTAIN CONSTANT EXHAUST DUCT STATIC PRESSURE.
4. VAV BOX MINIMUM CFM SHALL BE 120 CFM WHEN FUME HOOD IS OFF, 800 CFM WHEN FUME HOOD IS ON.
5. SUPPLY FAN VFD SHALL MODULATE TO MAINTAIN CONSTANT SUPPLY DUCT STATIC PRESSURE.
6. RETURN FAN VFD SHALL MODULATE TO MAINTAIN LAB SPACES AT SLIGHT NEGATIVE PRESSURE RELATIVE TO CORRIDOR.

3 LAB/PREP ROOM EXHAUST SYSTEMS

SCALE: NONE


EF 5
PREP ROOMS EXHAUST FAN
EF 2
SCIENCE LABS FUME HOOD EXHAUST FAN
RTU 3
SCIENCE LABS
EXTEND 18x22 EXHAUST DUCT 33" FROM RTU
EF 3
TOILET EXHAUST FAN
TRAPPED CONDENSATE PIPING, ROUTE TO NEAREST ROOF DRAIN. (TYP. ALL RTU'S)
RTU 1
CLASSROOMS
MAU 1
KITCHEN MAKE-UP AIR UNIT WITH HW HEATING
10'-0"
RS&RL DN TO AC-1,2,3
SEF 1
SEF 2
SEF 3
SEF 4
MOUNT SMOKE EXHAUST FANS ABOVE PLENUM ON ROOF CURB REFER TO DETAIL 3/M401
52"Wx12"L GALV. STEEL EXHAUST PLENUM (TYP. FOR 4).
28X30 STEEL SMOKE EXHAUST DUCTS UP FROM ATRIUM (TYP FOR 12)
ACC 1
ACC 2
ACC 3

FUSS & O'NEILL

January 15, 2020

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Nathan Hale School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Nathan Hale School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable ventilation code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 27, 2020 and remote building automation system (BAS) review on October 29, 2020, it is our opinion that the building's ventilation systems have significant deficiencies that will need to be addressed before the building can be reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Thirteen packaged rooftop units (RTU) and one makeup air unit (MAU) serve the building, equipped with direct expansion (DX) cooling and natural gas-fired burner for heating. These RTUs provide all of the building's mechanical ventilation and were installed in 2002. At 18 years old, these units are nearing the end of their useful lives (typically 15 to 20 years), and should be replaced in future renovation. All RTUs were operating with the exception of RTU-5, which serves the gym. MAU-1 was also not operating, which serves the Kitchen. Most RTUs have new MERV 13 filters currently installed. However, at the time of our visit, only half of the filters in RTU-9 were replaced and incorrectly-sized filters were installed in RTUs 5, 7, and 12, allowing air to bypass the filters. Also, filters in RTU-4 and 8 appear to have been damaged during installation. These issues were noted to the custodian during our visit.

Outdoor air (OA) dampers for most RTUs were also noted closed during our visit. Only RTU-1 OA dampers were noted open. Most exhaust fans (EF) were running. The exhaust fans serving the kitchen and science areas were not, which is acceptable when the rooms are not occupied. All occupied rooms were noted to have supply and return connections to an RTU. Rooms A210 and Media Center were noted to have a dirty return grille. The airflow in the ductwork above Hallway 13 was clearly audible, suggesting poor insulation or a fan bearing issue. The split AC unit in the Data Room was noted flashing error code P8, which indicates a potential compressor issue.

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Building Automation System Review Findings

Based on our remote review of the BAS, Gymnasium RTUs -5, -6, and RTU-13 (which serves the adjacent gymnasium lobby, locker rooms and gym office spaces) were experiencing high return air duct CO2 values (>900 ppm and 1341 ppm, respectively). Considering the gym was unoccupied at the time of review, the CO_2 readings in these units were inaccurate. This may be a sensor issue, however, both gym return air sensors were reporting near-identical values, leading to a possible alternate source of CO2. As these units utilize gas-fired heat, a potential source of CO2, these units should be immediately shut down and tested for leaks within their heat exchangers. If a heat exchanger is found to be leaking, it must be replaced. Taking the age of the unit into consideration, the entire RTU should be replaced if this is the case. This information was passed along to a New Haven school representative at the time of our visit.

In addition to the RTU issues, it was noted that the BAS itself should be upgraded at some point. In its current state, the HVAC system is not represented in sufficient detail and lack appropriate controllability in the BAS. At a minimum, the BAS should be able to control the dampers within each RTU. It is recommended that the BAS be upgraded to report actual damper position as well as the position commands from the BAS. The upgrade should also include graphics for VAV boxes, radiation, and other controlled distribution of heating and cooling.

Nurse's Suite

The Nursing Suite is made up of Rooms B218 and B220. During our visit, it was noted that one of the two rooms would be converted to an isolation room. Both rooms being considered have both supply and return connections to an RTU. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

1. Shut down RTU-5, 6, and 13 and check heat exchangers for leaks. If a leak is found, replace the unit. Do not re-open the building until these units have been shut down and inspected.
2. Replace any dirty or damaged filters in RTUs.
3. Confirm designated isolation room. Install a HEPA-filtered negative air machine to the isolation room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation. A portable HEPA filter is recommended to clean the air within the room during and after occupation.
4. Set toilet room and general exhaust fans to run 24/7.

5. Replace air handling equipment RA final filters with MERV 13 or better.
6. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
7. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied.

1. Clean dirty return grilles in Media Room and A210.
2. Upgrade BAS to allow control of dampers within RTUs.
3. Upgrade BAS to provide more detail on room temperature control, VAV boxes, radiation, and duct reheat coils.

As part of a future renovation, it is recommended to incorporate the following:

1. Establish a timetable capital planning to replace all RTUs as they are at the end of their useful lives.
2. Conduct a ventilation analysis of each single-zone RTU and VAV box system to determine the minimum outside air fraction required for each RTU.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: New Haven Academy – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the New Haven Academy School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 27, 2020 and remote building automation system (BAS) review on October 25, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

At the time of writing this report, no mechanical drawings of the building have been made available to us.

Field Observations

New Haven Academy was renovated in 2016. Ventilation is provided by three dedicated outdoor air systems (DOAS), two air handing units (AHU), two energy recovery ventilators (ERV), one heat recovery ventilator (HRV) and several exhaust fans. The DOAS units have hot water heating coils and chilled water cooling coils. They also have advanced humidity control capability, in which each unit contains an energy recovery wheel (ERC) and a cooler dryer quieter (CDQ™) wheel. Terminal equipment includes over thirty chilled beams and eight variable air volume (VAV) boxes with hot water reheat.

Most of the large air handling equipment was operating at the time of our visit. Filters in all equipment were in need of replacement, and in one case of DOAS-1, reinstallation to seal a large gap in filter coverage. The DOAS outdoor air (OA) dampers were noted as 100% open and return air (RA) dampers 0% open, which is a correct configuration. The outdoor air dampers on AHU-1 and AHU-2 were closed with RA dampers 100% open, which is not ideal given the mild outdoor air temperature at the time of the visit. Equipment sequence of operation should be revisited, and

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economizer mode should be enabled on all equipment to bring in more ventilation as outdoor conditions allow.

Building Automation System Review Findings

Based on our remote review of the BAS on October 25, 2020, the majority of the equipment was operational, although some controls issues exist. The ERC and CDQ wheels for DOAS-1 are disabled and the exhaust fan speed is shown at 0%. The CDQ wheel for DOAS-1 was disabled and the exhaust fan speed was shown at 4%. It is recommended to investigate these set points and exhaust fan operation. The DOAS-3 pre-filter differential pressure exceeded the set point, reflecting the dirty filter condition noted above. Outdoor air (OA) damper for AHU-1 was set at 20%, which is low for a temperate day. The ERVs and HRV appeared to be operating well with no filter alarms.

The majority of occupied rooms are served by radiant heating panels with supply diffusers as well as return grilles. Temperature sensors are located throughout the building. Security Office 109 is served by a split heat pump unit only and no obvious ventilation ductwork. An odor of cigarette smoke was in the room, which also indicates poor ventilation. Similarly, the offices adjacent to the gymnasium also lack ventilation ductwork and are served by split heat pump units.

Demand control ventilation (DCV) is possible for the two AHUs, as a CO_2 sensor is installed in the return air ducts, as well as CO_2 sensors at the individual zone level at the VAVs. Currently, the return air CO_2 set point is 950 ppm. We recommend lowering these set points to 600 ppm to maximize outdoor air damper positions. Minimum OA damper positions should be set to 30% to ensure constant ventilation during occupied hours, even if the CO_2 concentration drops below the set point.

Toilet exhaust fans and general exhaust fans were functioning during our BAS review. The Lab, Kitchen and refrigerant exhaust fans were off, as expected. However, radon exhaust fans EF-6 through EF-11 were enabled by the BAS but they were off with alarms. We recommend evaluating these fans.

Nurse's Suite

The Nurse's Suite (Room 112) consists of a large room with waiting area, curtained cot area and office. One dedicated toilet with exhaust is located in the suite. Room 114 has been identified as an isolation room, and contains ducted supply and return grilles with finned tube radiation along the exterior wall. It is recommended that a HEPA-filtered negative air machine be installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode.
2. Set general exhaust fans serving occupied areas to run constantly during occupied hours.
3. Replace air handling equipment RA final filters with MERV 13 or better.
4. Set minimum OA airflow in each AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
6. Evaluate and repair radon exhaust fan malfunction.
7. Install a HEPA-filtered negative air machine to the isolation room's return grille. Reduce supply air to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply diffuser to create a passive isolation room appropriate for short-duration occupancy.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Incorporate ventilation into Security and Gym offices.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:

Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
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- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Quinnipiac School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Quinnipiac School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. Based on our field observations on October 13, 2020 and remote building automation system (BAS) review on October 12, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and code violations that will need to be corrected, and re-evaluated before considering re-occupying the building. A summary of our findings and recommendations are shown below. A list of guidance documents is included as *Appendix A*.

Field Observations

At the time of our site visit, no mechanical ventilation was being supplied to the building. All classrooms and administrative offices are equipped with unit ventilators. However, the outdoor air louvers have been sealed shut, resulting in recirculation of indoor air within the space. All rooms with unit ventilators have operable windows, which were closed during the visit. The unit ventilator in the Principal's Office was reported as not operational. The cafeteria and kitchen are conditioned by an air handling unit (AHU) located in the attic. This unit has an outdoor air inlet, but the louver has been blocked with plywood from the outside of the building. Filters were not visually observable. At least one return grille was witnessed as sealed shut. The building has 12 exhaust fans, nine of which were operating during our site visit. The remaining exhaust fans were not running during the visit and are not observable via BAS. It is unknown why the exhaust fans were not operating. Throughout the building, many exhaust grilles were noted to be dirty or clogged. All observed mechanical equipment appeared antiquated and was reported to be original to the building. No building drawings were available for us to review this information.

Building Automation System Review Findings

The building's DDC system is limited and only serves the boiler system, one exhaust fan, and limited temperature readings. At the time of review, an alarm was active for hot water pump P-1.

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The outdoor air temperature was listed as 0°F on the miscellaneous points list, indicating a faulty sensor.

Nurse's Suite

The school Nurse's Office is located next to the Main Office and includes one bed and an attached dedicated bathroom. The office has an exhaust grille and no mechanical ventilation or windows. A storage room near the Cafeteria has been identified as an Isolation Room. This room has no ventilation or windows. Without modifications, this room is not suitable to be used as an isolation room

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Provide the building with a means of mechanical ventilation for all occupied rooms per code. This includes new and functioning outdoor air dampers on all air handling equipment.
2. Add ventilation equipment to the BAS and allow BAS to control and monitor the equipment. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode. Formally recommission the HVAC systems.
3. Clean dirty/clogged grilles.
4. Investigate alarm associated with P-1.
5. Investigate possible faulty outdoor temperature sensor.
6. Ensure all exhaust fans are operable and run continuously. Run air handling unit supply fans to balance the building.
7. If possible, duct a new return in the isolation room to the existing air handler. Install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Install an exhaust fan to exhaust isolation room air to the outdoors. If this is not possible, the room may remain unventilated to create a passive isolation room appropriate for short duration occupation. A portable HEPA filter-fan should be installed to decontaminate the air within the room during and after occupation.

As part of a future renovation, it is recommended to incorporate the following:

1. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.
2. Additional space CO2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
3. Replace aging air handling equipment.
4. Consider adding complete AHU-1 and exhaust fan graphic sets that show command, status and alarm. The exhaust fans are an important part of the overall building ventilation.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

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- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Riverside Academy School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Riverside Academy School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable ventilation code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 1, 2020 and remote building automation system (BAS) review on October 30, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and will need to be addressed before the building can be reoccupied. A summary of our findings and recommendations are shown below.

At the time of writing this report, no mechanical drawings of the building have been made available to us.

Field Observations

One air handling unit (AHU), two rooftop units (RTU) labeled "RTU-4" and "New RTU-1", and five exhaust fans (EF) serve the building. These units contain hot water heating coils and direct expansion (DX) cooling coils and provide the building's ventilation. Nine variable air volume (VAV) boxes fine tune air delivery temperature to each zone served by the AHU and RTU-4, aged 19 and 20 years, respectively. New RTU-1, aged 19 years, serves the gymnasium as a single zone. Typical expected lifespan of DX cooling units is 15 years, and these units should be planned for replacement in the near future. At the time of our site visit, some of the air handling equipment was running. The AHU was undergoing repair during our visit and was not in service. "New RTU-1" serves the gymnasium and was functioning. The filters in this unit were noted close to end of life and should be replaced. RTU-4 was not operating at the time of our visit, and filters were noted in need of replacement. Outdoor air (OA) dampers were noted as partially open in the BAS. A relief intake hood on the roof marked "not in use" was noted not secured to the rooftop. The AHU and RTU-4 need to be functioning as designed before the building can be reopened.

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Individual classrooms are ventilated by the AHU via VAV boxes. Further temperature control within each classroom is provided by mini-split air conditioning (AC) units and baseboard radiation along outside walls. The main office utilizes two window AC units. Damaged insulation was noted in the mechanical room, which may allow condensation on the cold ductwork to occur. This insulation should be replaced to prevent mold growth and reduce operating costs.

All occupied rooms were noted to have both supply and return connections. Toilet rooms are equipped with exhaust fans and radiant heating. The Teacher's Lounge and Music Room were once a combined room that has since been partitioned. As there was only one return grille in the original space, the Music Room only has supply air diffusers and no return grilles. The office for the gym teacher was also noted has missing an air return. The teacher's conference room adjacent to the main office was noted to have a malfunctioning split AC unit. A damaged thermostat was noted in one of the classrooms.

Building Automation System Review Findings

Based on our remote review of the BAS on October 29, 2020, available equipment information on the BAS is limited. It is our opinion that the building's ventilation systems have some deficiencies and will need to be addressed before the building can be occupied. RTU-1 through -3 have been removed from the rooftop but still exist in the BAS. These units should be removed from the BAS for clarity. New RTU-1's OA damper position is at 46% but the exhaust air damper position is at 0%. This inconsistency indicates sensor or damper malfunction. The New RTU-1 RA CO_2 sensor is also reading slightly lower than expected.

The AHU-1 return air (RA) CO_2 sensor has abnormally low value, indicating sensor drift due to age. Demand control ventilation (DCV), which uses CO_2 readings to modulate outdoor air intake, is possible for these air handling units; however, if the CO_2 sensors are not functioning properly, DCV cannot be achieved. Sensor replacement as well as lowering the CO_2 setpoint to 600 ppm is recommended. The minimum OA damper position should be set to 30% for all units to ensure ventilation during all occupied hours. Only two of the five exhaust fans are represented in the BAS. All general purpose exhaust fans should be scheduled to run during all occupied hours.

The hot water system, which consists of a single boiler and 5 zone pumps, is enabled but not operating correctly. The hot water differential sensor is malfunctioning with an alarm. Hot water supply and return temperatures are also not available in BAS. Not all exhaust fans are indicated on the BAS. All exhaust fans should be set to run continuously during occupied modes.

Nurse's Suite

The Nurse's Suite consists of a single room which serves as a waiting area, office, and examination area, as well as one dedicated toilet with exhaust. A new isolation room was identified adjacent to the teacher's lounge. This room has ducted supply and exhaust shared with other nearby rooms.

It is recommended that a HEPA-filtered negative air machine be installed in the room's return duct and the supply be sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Confirm AHU and RTU-4 are in functional condition.
2. Replace AHU and RTU filters with MERV 13 or better.
3. Set minimum OA airflow in each RTU and AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
4. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
5. Set all general purpose exhaust fans to run during all occupied hours.
6. Investigate and correct sensor issues within AHU-1 and RTUs.
7. Replace damaged insulation on AHU ductwork.
8. Install return grille in Music Room and Gym Teacher's office. Connect to ductwork above ceiling.
9. Replace broken thermostats.
10. Evaluate OA damper position inconsistency in New RTU-1.
11. Install a HEPA-filtered negative air machine to the isolation room's return grille. Reduce supply air to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply diffuser to create a passive isolation room appropriate for short-duration occupancy. An exhaust fan through a window or outside wall is recommended in this case and will negatively pressurize the space to prevent cross-contamination with adjacent spaces.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Repair hot water differential sensor.
2. Incorporate hot water supply and return temperatures into BAS to monitor boiler and zone pump function.

3. Incorporate all exhaust fan control and status points on BAS. Include in occupancy schedule.
4. Repair split AC unit in Teacher's Conference Room

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Replace aging equipment.
4. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
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- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Ross Woodward Magnet School – HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Ross Woodward Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable ventilation code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 27, 2020 and remote building automation system (BAS) review on October 23, 2020, it is our opinion that the building's ventilation systems have significant deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Ross Woodward Magnet School was renovated in 2004. Ventilation is provided by fourteen (14) rooftop units (RTU), one make-up air unit (MAU) and twenty four (24 exhaust fans. Some of these RTUs have gas-fired burners and others have hot water coils for heating. All units have direct expansion (DX) coils for cooling. RTUs supply zone VAV boxes with hot water reheat coils.

The rooftop units were running but were generally unmarked, which creates confusion in the field. We recommend clearly relabeling each units to match the tags within the BAS. Filter sections were not observable on most of the rooftop units as the doors were bolted shut. In some units, both the outdoor air (OA) and return air (RA) dampers were closed. This is an unacceptable condition, as the supply fan is pulling against two closed dampers. Many other rooftop unit OA dampers were also noted closed. The controls engineer was alerted to this condition during our field visit as it appeared the building had very little mechanical ventilation.

Most of the exhaust fans (EF) were also either not operating or not exhausting air at the time of our visit. Motors were running on several fans but no air movement was detected. The drive belt was observed disconnected on EF-20. We recommend evaluating all exhaust fans for belt replacement.

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Building Automation System Review Findings

Based on our remote review of the BAS on October 22, 2020, sensors and controls in some RTUs require attention. Outdoor air (OA) dampers for RTU-4 and RTU-5 were set to 0%. RTU-7 and RTU-13 were not available on the BAS for observation. All other RTU OA dampers were set between 25% and 50% open. Given the disagreement between the BAS and field observations, damper linkages and sensors should be evaluated. It is recommended to maximize outdoor air by enabling economizer function, especially during shoulder seasons. Exhaust fans for RTU-10 and RTU-11 were enabled but in the 'off' status. Demand control ventilation (DCV) does not seem possible in this building as there are no return air or room CO_2 or relative humidity (RH) sensors to monitor ventilation effectiveness.

Temperature readings of the entire building are within the acceptable range, with the exception of Rm-B207, which was very hot on both the BAS and during our field visit. The radiant heating valve serving this room should be evaluated. Given the temperate weather, acceptable temperature ranges may not indicate larger problems within the system.

Individual toilet exhaust fans are not available on the BAS and should be added to monitor and control run status. Based on the latest ventilation guidelines, general exhaust fans should be running continuously during occupied modes.

Return grilles in the Cafetorium appeared to be clogged and in need of cleaning. The split unit serving the Communications room appeared in need of repair. Returns in gymnasium are damaged and in need of replacement.

An odor was noted in the mechanical room, indicating very poor ventilation. Design drawings do not indicate a dedicated exhaust for this space – only one supply fan is shown to provide boiler combustion air. An exhaust fan serving this area should be installed immediately. Michael Pinto was notified of this condition while we were on site, as accumulation of gases and fumes can create a very dangerous condition. CO sensors should also be installed in this space with both audible and BAS integrated alarms.

Nurse's Suite

The Nurse's Suite consists of two offices, a waiting area, two exam rooms, one cot area, and two dedicated toilet rooms with exhaust. Two isolation rooms have been identified: The Nurse's office (Room 1429) and one of the exam rooms (Room 1447). The entire Nurse's Suite is served by VAV-12, which is connected to RTU-9. This RTU also serves all of the first floor administrative offices. It is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Modify air handling equipment controls to provide ventilation during the entire scheduled occupancy period. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode.
2. Set toilet room and general exhaust fans to run 24/7.
3. Replace air handling equipment RA final filters with MERV 13 or better.
4. Evaluate and repair all exhaust fans.
5. Ensure all outdoor air dampers are functioning properly in relation to the BAS. Review sequence of operations to prevent closure of both OA and RA dampers simultaneously.
6. Install new exhaust fan in mechanical room with audible CO detection alarms. Tie all functionality into BAS.
7. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
8. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
9. Install a HEPA-filtered negative air machine to the isolation rooms' return grilles. Reduce supply air to both rooms to ensure a negatively pressured environment. If a HEPA-filtered negative air machine is not able to be acquired, block off supply diffuser to create a passive isolation room appropriate for short-duration occupancy. An exhaust fan through a window or outside wall is recommended in this case and will negatively pressurize the space to prevent cross-contamination with adjacent spaces.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied.

1. Label all rooftop equipment.
2. Repair radiant heating valve serving room B207.
3. Repair Communications Room split AC unit.
4. Clean gymnasium return grilles.

5. Incorporate missing RTU information into BAS for monitoring and control.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Sound School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Sound School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 1, 2020 and remote building automation system (BAS) review on October 8, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

The Sound School is made up of five buildings: the Aquaculture Building, the Anderson Building, the Thomas Building, the McNeil Building, and the Emerson Building. The Aquaculture Building is the most modern of the five buildings, with the other four being far smaller buildings of basic construction. Packaged rooftop units (RTU) provide each building with heating, cooling, and mechanical ventilation. Heating is supplemented by hydronic baseboard radiation. The Anderson, Emerson and Thomas buildings are each served by one RTU. The McNeil building is served by two RTUs, and the main building is served by six RTUs and four make-up air units (MAU). The RTUs are all equipped with natural gas heating and DX cooling. Although the units were reported to function properly, none of the RTUs were running during the site visit, likely due to the mild weather. All units were installed in 2002 and were noted to be equipped with new MERV 8 filters dated June 2020. Upon opening the units, the outdoor air (OA) damper positions were not observable and should be confirmed by facility personnel.

Most of the occupied spaces across the five buildings have both supply and return connections to an RTU, with some exceptions. In the McNeil building, the social worker suite has supplies in each room, but only one return in the corridor just outside the three rooms. It is recommended that a

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return grille is installed in each room and connected to an RTU return duct. Classroom 112 in the Emerson building has a supply but no return. In the Thomas building, the Special Education Coordinator's office has neither a supply nor return and the conference room has no return. The Aquaculture Building and the Anderson Building have both supply and return connections in all occupied spaces. Room 718 in the Aquaculture Building has salt crystals forming from the ceiling due to a slow leak in the saltwater circulation system above.

Building Automation System Review Findings

Based on the review of the building's BAS, some system repairs are necessary prior to re-opening the building. There is no mention of CO_2 sensors within the BAS, meaning that demand-controlled ventilation is likely not available. In general, the outdoor air (OA) dampers in the RTUs should be set to maximize ventilation into each building without the risk of freezing the RTU coils. We recommend setting the minimum OA damper position in each unit to 30% open during occupied hours with freeze protections in place to close as required ONLY to avoid coil freezing. See recommendations.

In the main building, issues were noted in many of the VAV boxes. Common issues were abnormal temperatures and flow rates of zero being reported. The entire VAV system should be investigated and repaired prior to re-opening the school. The RTU labeled AC-2M in the McNeil building showed a supply air temperature far lower than the outdoor air temperature (39°F SA vs. 65°F OA), indicating a temperature sensor issue. In all buildings, the RTU graphics do not show a DX cooling set point and show incorrect exhaust and return air damper position tracking. Proper operation of the RTU units should be confirmed prior to re-opening. Eventually, the BAS should be updated to accurately reflect the RTU unit systems.

Exhaust fans are represented in the BAS, but the status points would not load during the review. It is recommended that all general and toilet room exhaust fans run constantly during occupied hours.

Nurse's Suite

At the time of the site visit, no isolation room had been identified. Once a room is identified to be converted into an isolation room, it is recommended that a HEPA-filtered negative air machine is installed in the room's return duct and the supply is sealed off to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Identify an isolation room. Install a HEPA-filtered negative air machine to the isolation room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment.
2. Replace all RTU filters with MERV 13 or greater.
3. Thomas Building: Install ducted supply and return in Special Education Coordinator's office. Install return in Conference Room.
4. Install supply diffusers and return grilles in occupied spaces that do not currently have supply or return connections to an RTU.
5. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
6. Investigate and repair or replace faulty sensors across all buildings, such as the RTU AC-2M supply temperature sensor.
7. Investigate RTU unit operation against what is shown in the BAS. Re-commission all RTUs to ensure proper unit operation.
8. Schedule all general purpose exhaust fans to run constantly during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Update the BAS to accurately reflect the functionalities of the RTUs.
2. Emerson Building: Install return in Classroom 112.
3. McNeil Building: Install return grilles in the social worker suite and connect them to an RTU return duct.
4. Investigate the Aquaculture Building's VAV system. Repair or replace faulty sensors and ensure that the system is operating properly.

As part of a future renovation, it is recommended to incorporate the following:

5. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.

6. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
7. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Strong Magnet School – Preliminary Report of HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Strong Magnet School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable ventilation code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on December 15, 2020 and remote building automation system (BAS) review on December 22, 2020, it is our opinion that the building's ventilation systems have deficiencies and will need to be addressed before the building can be occupied. A summary of our findings and recommendations are shown below.

At the time of writing this report, no mechanical drawings of the building have been made available to us.

Field Observations

Strong Magnet School was renovated in 2004, and was used for many years as a classroom swing space. The building has remained vacant for nearly a year, and there are no immediate plans to reuse this space as a school.

Ventilation is provided by three (3) rooftop units (RTU), which serve the multipurpose room and administrative areas, thirty (30) classroom unit ventilators (UV), and twenty-four (24) exhaust fans (EF). The RTUs have natural gas heating and DX cooling. The UVs each have an associated condensing unit (CU) located on the roof for DX cooling and have hot water heating coils. The hydronic hot water is provided by two oil/gas-fired boilers. During the visit, none of the RTUs or EFs were running. The school has been unoccupied for over a year, as the building is typically used as classroom swing space. During occupied mode, all general purpose EFs should run continuously. UVs were all running and in heating mode. UVs in rooms 107, 108, 109, and 110 were blocked by boxes or supplies, as these rooms were being used for storage rather than

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classrooms. Filters and outdoor air (OA) dampers were not accessible in any unit during the site visit. If possible, the final filters in all RTUs and UVs should be replaced with MERV 13 or above.

Most occupied rooms have supply and return connections to a UV or RTU for mechanical ventilation. The kitchen office was noted to have return grilles, but no supply diffuser. The administrative offices have floor diffusers and room 146 does not have a return grille. Dirty exhaust grilles were noted rooms 104, 105, 106, 209, and many of the building's restrooms. Broken supply diffusers were noted in the second floor hallway. A gas odor was noted in room 203 and was reported to the custodian. The maintenance staff have been notified of the odor prior to the writing of this report. Non-gas odors were also noted in rooms 105, 106, and 208. Ceiling tiles are also falling throughout the building, likely due to leaks above the ceiling.

Building Automation System Review Findings

Based on our remote review of the BAS on December 22, 2020, the system is in need of attention prior to re-opening the building. All three RTUs are capable of utilizing demand-controlled ventilation, which should be enabled. The CO_2 set point should be set to 600 ppm to maximize ventilation and minimum outdoor air (OA) damper positions should be set to 30% to ensure ventilation during all occupied hours.

The majority of UVs show an economizer position of zero, meaning no OA is entering the unit. In order for the building to be properly ventilated per the building code, the UVs must bring OA into the spaces they are serving. There is also a note that all UVs run off of the OA sensor in room 132. Each UV should be equipped with its own sensors to ensure proper operation. Some UVs do have positive economizer positions, but they are only listed as 4.00 or 9.00. It is unclear if these are percentages or arbitrary numbers from a zero to ten scale. In addition to the UV issues, no exhaust fans are represented in the BAS. It is recommended that exhaust fan status is added to the system and that all general purpose exhaust fans are scheduled to run constantly during occupied hours.

Nurse's Suite

No isolation room has been identified for this building, as there are no plans to use it as a school. If this changes and the building does return to occupancy as a school, an isolation room will need to be identified and the room's HVAC system will need to be modified to follow ASHRAE recommendations for isolation rooms.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. Restore RTUs and UVs to working conditions.

2. Set UVs to intake OA in order to ventilate spaces served. Set minimum OA damper position to 30%
3. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
4. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
5. Set general purpose exhaust fans to run constantly during occupied hours and add all exhaust fans to BAS.
6. If possible, replace air handling equipment RA final filters with MERV 13 or better.
7. Move storage blocking UVs in rooms 107, 108, 109, and 110.
8. Investigate gas odor in Room 203.
9. Repair collapsed ceilings and inspect area above ceilings for possible leaks.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Investigate odors in rooms 105, 106, and 208.
2. Clean all dirty or clogged exhaust grilles.
3. Install OA sensors on each UV so that they no longer all run off of Room 132.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to the BAS to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Add CO2 sensors to areas with high populations, including classrooms, Nursing suite, and conference rooms to monitor ventilation adequacy.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Troup School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Fair Haven School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 22, 2020 and remote building automation system (BAS) review on October 23, 2020, it is our opinion that the building's ventilation systems have significant deficiencies that will need to be corrected and re-evaluated before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

Five rooftop air handling units (RAHU), five indoor air handling units (AHU), and twenty exhaust fans (EF) serve the building, installed in 2007. These RAHUs and AHUs provide all of the mechanical ventilation for the school and are equipped with hot and chilled water coils. The AHU and RAHU filters were replaced in June 2020 and all appeared to be clean and undamaged. RAHU-1 and 4 have MERV 8 filters installed, RAHU-2 and 3 have MERV 8 and MERV 14 filters installed, and the filters for RAHU-5 were inaccessible during the site visit. AHU-1, 2, 3, 4 and 5 all have MERV 8 and MERV 11 filters installed. The RAHU outdoor air dampers were not observed during this site visit. The testing and balancing (TAB) contractor will document details of the outdoor air dampers during an upcoming visit. With the exception of AHU-1, which had an outdoor air damper that appeared to be mostly closed, all indoor AHUs were observed to have open OA dampers. All occupied rooms are equipped with both supply and return diffusers/grilles to provide airflow to/from an AHU or RAHU. Some of the return grilles in the gym were noted to be damaged.

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Building Automation System Review Findings

During the review of the building's BAS system, most of the AHUs were in operational condition; however, there are some issues. AHU-1 OA damper was set to 15%, but reading 0 cfm. AHU-4 OA damper was set to 100%, but reading 0 cfm. AHU-5 was shown to have a closed OA damper, but also shown to be in economizer mode, which was incorrect. RAHU-3 was also shown to have an OA flow rate of 0 cfm. RAHU-4 had a high duct static alarm. All RTUs have existing demand controlled ventilation. Target CO_2 ranges should be set to 600 ppm to maximize outdoor air intake to the building. Minimum OA damper positions should be set to 30% to ensure ventilation during all occupied hours.

During the DDC review, all EFs were turned off and in unoccupied mode. All general duty EFs should be running while the building is occupied. Beyond ventilation issues, boiler B-1 was in alarm status and hot water pump HP-1 was enabled, but the pump was shown as off.

Nurse's Suite

The school nurse's office is located within a health suite that includes a reception area, the nurse's office with three cots, each with a curtain, an exam room, two offices, a conference room, and a bathroom. The security office (A005) down the hall from the health suite is being converted into the school's isolation room. This room was inaccessible during the site visit, but the drawings show that it was a storage room before becoming the security office and is equipped with a supply diffuser, but no return, exhaust, or operable windows. The supply diffuser should be sealed off to create a passive isolation room appropriate for short-term occupation. Rooms without return grilles will become slightly pressurized during occupied airflows, resulting in air spilling into adjacent spaces. Patient areas should be neutral or negatively pressurized for this reason. A portable HEPA filter unit should be installed in the room to remove aerosols and fine particles during and after use.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Investigate physical damper position, fan status, and sensors to diagnose malfunction within AHU-1, 4, and 5 and RAHU-3.
2. Investigate alarms associated with B-1 and RAHU-4.
3. If possible, upgrade filters in all RAHUs and AHUs to MERV 13.
4. Close off isolation room supply diffuser to create a passive isolation room during occupation. Install a portable HEPA filter unit within the room.
5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.

6. Set minimum OA airflow in each RAHU and AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
7. Set all general purpose exhaust fans to run continuously during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace damaged grilles/diffusers.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.
3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room with supply and return grilles, as well as Normal and Isolation HVAC modes with negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:

Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

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- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
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- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
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- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
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- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Truman School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Truman School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 1, 2020 and remote building automation system review on October 13, 2020, it is our opinion that the building's ventilation systems have deficiencies that should be addressed before the building is reoccupied. A summary of our findings and recommendations is shown below.

Field Observations

There are eight packaged rooftop units (RTUs) serving the building, and provide all of the building's outdoor air and are equipped with direct expansion (DX) cooling and natural gas heating. These units feed 61 fan-powered VAV boxes with hydronic reheat coils, and were installed as part of the HVAC renovation in 2003. These units are near the end of their expected lives (typically 15 years). During the visit, all RTUs were operational except RTU-3, which has active alarms in the building automation system (BAS), and RTU-8, which serves the gym. At the time of our site visit, air filters and outdoor air (OA) dampers were not accessible in RTU-1, 2, 4, 5, 7, and 8. RTU-3 and 6 were equipped with MERV 8 filters that appeared to have been recently replaced. If possible, final filters in all RTUs should be replaced with new MERV 13 filters. OA damper positions were not visible during the site visit, but available drawings indicate minimum OA supply is dictated by CO_2 sensors via demand controlled ventilation (DCV). Within the building, variable air volume (VAV) boxes with hot water reheat coils control the airflow into each room from the RTUs.

Most occupied rooms have both supply and return connections to an RTU for mechanical ventilation. Work room 127, gym offices 133A and 135A, and classroom 209 were noted to have supply diffusers, but were missing return grilles. At the time of the site visit, dirty return grilles were

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noted in many classrooms and damaged supply diffusers were noted in the Principal's Office, both locker rooms, and gym office 135A.

Building Automation System Review Findings

Based on our remote review of the BAS, the presence of RH and return air CO2 readings for each RTU allow for demand-controlled ventilation and indicate the adequacy of ventialtion, but there is no indication of outdoor air (OA) damper positions or airflow rates for any RTU within the BAS. A separate 'miscellaneous' tab indicates dehumidification activity, night purge, static pressure, and damper minimum position. This information should be incorporated into the RTU main graphic for ease of use.

Based on the CO_2 readings within the building, the units are adequately ventilating the space and sensors appear to be functioning correctly. In order to maximize ventilation, demand-controlled ventilation should be enabled and the CO_2 set point should be 600 ppm. The BAS should be modified to monitor OA damper positions and the dampers should be set to have a minimum position of 30% open if the current sequence of operation does not already dictate a minimum position. Each RTU should also be inspected to confirm that the dampers operate as they are commanded to by the BAS. At the time of the system review, RTU-3 and RTU-6 displayed a supply fan failure.

Zone VAV box graphics show room served, damper positions, airflow rates, and control the radiant heating in each zone. 14 hydronic controllers activate hydronic radiation in toilet rooms and areas not served by a VAV box. MAU-1 serving the Kitchen does not appear to be referenced on the BAS. The Occupied Mode schedules were not able to be determined from within the BAS, but were reported by New Haven to be 4am-10pm. This schedule should be made more easily discoverable. General purpose exhaust fans were also not represented in the BAS. It is recommended that all general purpose exhaust fans are scheduled to run constantly during occupied hours. Any out-of-range values, such as room temperatures, should be color coded for ease of discovery.

Nurse's Office

The school nurse's office is located within a health suite that includes two offices, two exam rooms, a reception area, and a main laydown area. Security Office 123 has been identified as an isolation room and is equipped with a supply and return grilles as well as operable windows. The entire health suite and isolation room is conditioned and ventilated by RTU-6. This unit recirculates air through these areas as well as the first floor administrative areas. It is recommended that a HEPA-filtered negative air machine is installed in the isolation room's return grille. The supply diffuser should be blocked off to ensure the space is negatively pressured.

Recommendations

Prior to re-opening the building, it is recommended that the following measures be implemented:

1. If possible, replace RTU filters with MERV 13.
2. In the isolation room, install a HEPA-filtered negative air machine to the room return (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
3. Maximize outdoor air dampers during shoulder seasons and incorporate purge mode.
4. Set minimum OA airflow in each RTU to 30% if the existing control sequence of operation does not dictate a minimum. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
5. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
6. Address all active alarms and possible temperature sensor malfunction within RTU-1.
7. Confirm that all general purpose exhaust fans run constantly during Occupied Mode.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Consider adding complete MAU-1 and exhaust fan graphic sets that show command, status and alarm. The exhaust fans are an important part of the overall building ventilation.
1. Improve BAS functionality by incorporating 'miscellaneous' information into equipment graphics. Color code out-of-range readings to improve error discovery.
2. Modify the BAS to include an exhaust fan graphic set that shows command, status, and alarm for each fan.
2. Clean dirty or clogged diffusers/grilles in Classrooms.
3. Replace damaged diffusers/grilles in the Principal's Office, both locker rooms, and the PE office near the Boys' Locker Room.

As part of a future renovation, it is recommended to incorporate the following:

3. Additional space CO2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
4. Replace aging RTUs.
5. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

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Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: West Rock STREAM Academy - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the West Rock STREAM Academy. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. West Rock STREAM Academy has one main building and two modular buildings. Based on our field observations on October 22, 2020 and remote building automation system (BAS) review on November 12, 2020, it is our opinion that the main building's ventilation systems have significant deficiencies and code violations that will need to be corrected before the building can be occupied. A summary of our findings and recommendations are shown below. A list of guidance documents is included as *Appendix A*.

Field Observations

All classrooms spaces are equipped with one wall-mounted exhaust grille, no supply diffusers were observed. This exhaust grille is often located behind storage cabinets with closed doors, which are currently obstructing airflow. An investigation of the building and roof showed no evidence of air handling equipment in the building. There is a locked access door to a possible fan room on the roof but the school staff did not know of a key to the door or when anyone would have been in there last. Based on our observation, the building does not have proper mechanical ventilation.

All cooling is provided by Samsung or Mitsubishi Heat Pumps. Many of the Samsung units had a digital controls readout either in the room or in a central area depending on the location of the unit. These digital readouts indicated filter changes are needed in all units and that there is a possible error in their communication (error code E201). All heating is provided by hot water radiant baseboard heat.

Two classrooms are located in a modular construction-style building detached from the main building. Each classroom is served by a packaged roof-top Trane unit and are individually controlled via temperature sensors in each classroom. It is not known if the units are electric or gas-

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fired, but they are presumed to utilize gas-fired heating and DX electric cooling. The rooftop units themselves were not accessible for observation due to their location and lack of access. Drawings of the buildings for this school were not available to us for review.

Building Automation System Review Findings

During the review of the building's BAS, it was noted that the system is has limited capabilities and was not functioning as much more than a time clock for occupancy modes, with some monitoring and on/off control of the boiler plant based on the measured temperatures. The only room temperature information is shown on the boiler tab where temperatures are displayed for 5 zones. Temperature set points are available from the boiler page, which also indicates boiler function. The rest of the temperature controls for the building are most likely pneumatic. One exhaust fan is indicated but was not able to be confirmed in the field. At the time of review, all measured temperatures, set points and status points read values of 0.0. This has been reported to the school system for repairs.

There is no information available within the system regarding outside air (OA) ventilation. Prior to re-opening this building, the BAS should be commissioned to ensure the limited capabilities that it does have are functional. The existing pneumatic system should be restored to best control individual room temperatures.

Nurse's Suite

The school nurse's office is located within a second modular construction-style building that includes office space, a reception area, the nurse's office, exam rooms, and a bathroom. This portable building has a separate electric forced-air heating and cooling system independent from the rest of the school. The two outdoor wall-mounted air handling units that supply the building and are controlled via the thermostat in the office manager's office. The school has established two isolation rooms within this building. One is in the office adjacent to the nurse's office and the other is in a conference room across the hall. Each room is equipped with a supply and return as well as a window. It is recommended that a HEPA-filtered negative air machine is installed in the return duct of each isolation room. Each room's supply should be closed to ensure a negatively-pressured environment.

Other Observations

During the inspection of the boiler room, in the basement, it was noted that there was approximately 1-3" of standing water. While it appeared there were sumps and sump pumps present, they did not appear to be functioning. Standing water can promote mold growth, turn septic, harbor bacteria, and be a significant health hazard. It is recommended the source of this water be found and repaired and all current standing water be removed.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Additional ventilation equipment and appropriate air distribution system should be incorporated to provide an outside air supply to all occupied spaces in the main building.
2. Gain access to the fan room on the roof and investigate what equipment is present and what condition it is in and if it is in need of replacement.
3. If possible, upgrade filters in all units serving the Portable buildings to MERV 13.
4. Replace filters and perform regular maintenance on the Samsung and Mitsubishi Ductless units and investigate possible communications error.
5. A HEPA-filtered negative air machine should be installed in each isolation room's return grille and the supply-side volume damper partially closed to ensure a negatively pressured environment within each room. . If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
6. Remove all items from the cabinets containing the return grilles for each room and leave cabinet doors open to promote air return.
7. Commission the BAS to ensure functionality.

As part of a future renovation, it is recommended to incorporate the following:

1. Upgrade or replace the BAS to include all building systems and improve system control capabilities.
2. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
New Haven, CT 06519

via email: phillip.penn@nhboe.net

RE: Wexler-Grant School - HVAC Mechanical Assessment Final Report

Dear Mr. Pinto:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Wexler-Grant School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, sand provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on October 22, 2020 and remote building automation system (BAS) review on October 27, 2020, it is our opinion that the building's ventilation systems have significant deficiencies and will need to be corrected and re-evaluated before considering re-occupying the building. A summary of our findings and recommendations are shown below.

At the time of writing this report, no mechanical drawings of the building have been made available to us.

Field Observations

Six packaged rooftop units (RTU), one indoor air handling unit (AHU), twenty-eight unit ventilators (UV), and a number of exhaust fans serve the building. The RTUs and AHU were installed in 2002. These units are in functional condition. However, they are considered approaching the end of their useful lives and should be replaced in the near future. Along with the classroom UVs, these units provide all of the mechanical ventilation for the school. The RTUs are equipped with hot and chilled water coils, while the AHU has hot water coils and DX cooling. The filters and outdoor air (OA) dampers in RTU-1, 2, 3, 5, and 6 were inaccessible during the site visit. RTU-4 had MERV 8 filters installed that were dated June 2020 and appeared to be clean and undamaged. The RTU-4 OA damper was noted to be partially open. AHU-1 also had recently installed MERV 8 filters, which were clean and undamaged. Its OA damper was closed.

Zones served by an AHU or RTU are further conditioned by nine fan coil units and sixteen shut-off variable air volume (VAV) boxes with reheat coils. Rooms not ventilated by an AHU or RTU

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are designed to be ventilated by a UV. However, the UVs were observed to have sealed OA louvers, resulting in no ventilation being provided to the twenty eight (28) perimeter rooms. This condition does not meet code and will need to be addressed before the building can be reopened. The MERV 8 filters in the UVs were not dated, but were noted to be very dirty and should be replaced. Rooms served by UVs have a return or exhaust grille. Without drawings it is unclear how the exhaust/relief system is configured.

During the site visit, four of the five accessible roof-mounted exhaust fans were not running. All occupied rooms without UVs are equipped with both supply and return diffusers/grilles to provide airflow to/from one of nine fan coil units (FCU), which receive ventilation air from an RTU. The kitchen office has a supply connection, but no return or exhaust. Grilles and diffusers in the main office area, library, and cafeteria were noted to be in need of cleaning. Damaged diffusers were noted in the gym and should be replaced.

Building Automation System Review Findings

Based on our remote review of the BAS, the majority of units require attention. No damper positions are reported for the AHU or RTUs. There is also no CO_2 monitoring or mixed air temperature reporting. Currently, the only way to monitor the OA entering the building is to physically look at the damper position at each unit. In the future, the BAS should be upgraded to allow remote ventilation control and monitoring. In the short term, the dampers should be adjusted to allow maximum OA to enter the system without risk of freezing the water coils. OA damper positions should be set to a minimum of 30% open to ensure ventilation during all occupied hours. Occupied hours are currently scheduled in the BAS as 4 am to 10 pm.

Control points on many of the VAV boxes appear to have issues. Many of the boxes show 100% open dampers, but no airflow. Flow through VAV-B128 and C102 were noted to significantly diverge from set point. In order to operate as designed, it is recommended that the VAV system be re-commissioned. The temperature sensor in room A113A appears faulty with a reading of 256°F. During the site visit, temperatures were noted to fluctuate both above and below the set points in many rooms. Exhaust fan status is not included in the BAS. It is recommended that all general purpose exhaust fans be set to run constantly while the building is occupied and status points be included in a future BAS renovation.

Nurse's Suite

The school nurse's area includes a cot area, with three cots and privacy curtains, an office, an exam room, a storage room and dedicated bathroom. The exam room will be used as one of the school's isolation rooms. Room A-114 was also identified as an isolation room. Both rooms have supply and return connections to an AHU or RTU, which is likely to recirculate air throughout other areas

within building. It is recommended that a HEPA-filtered negative air machine is installed in each room's return duct and the supply air reduced to ensure a negatively-pressured environment.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Restore unit ventilator outdoor air damper operation to ventilate classrooms.
2. If possible, upgrade filters in all RTUs and AHUs to MERV 13. Replace UV filters.
3. A HEPA-filtered negative air machine should be installed in the isolation room's return grille. Reduce supply air to ensure a negatively pressured environment. If a HEPA filter cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.
4. Re-commission VAV system to ensure proper operation.
5. Set minimum OA airflow in each RTU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
6. Investigate and repair or replace faulty sensors.
7. Set all general purpose exhaust fans to run continuously during occupied hours.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Replace damaged diffusers in the gym.
2. Clean dirty or clogged grilles/diffusers throughout the building.

As part of a future renovation, it is recommended to incorporate the following:

1. Additional space CO_2 measurement points should be added to give visibility to the adequacy of outside air ventilation after re-occupation by students and staff.
2. Conduct a ventilation analysis of each VAV and single-zone RTU system to determine the minimum outside air fraction required for each RTU and minimum VAV box damper settings.

3. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

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FUSS & O'NEILL

January 15, 2021

Mr. Phillip Penn
Chief Financial Officer
New Haven Public Schools
54 Meadow Street
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via email: phillip.penn@nhboe.net

RE: Wilbur Cross High School - HVAC Mechanical Assessment Final Report

Dear Mr. Penn:

Fuss & O'Neill conducted an evaluation of the ventilation systems at the Wilbur Cross High School. The purpose of the evaluation is to determine if the building's ventilation systems meet applicable code requirements and the latest school reopening guidelines, and provide improvement recommendations to reduce the possibility of airborne viruses in the building. A list of guidance documents is included as *Appendix A*.

Based on our field observations on September 18 and 23, 2020 and remote building automation system (BAS) review on October 8, 2020, it is our opinion that the building's ventilation systems have deficiencies and should be addressed before the building is reoccupied. A summary of our findings and recommendations are shown below.

Field Observations

There are seven (7) rooftop units (RTU) twenty-four (24) air handling units (AHU), and fifty-six (56) exhaust fans that serve the school located both on the roof and inside the building. The RTUs and AHUs utilize hot and chilled water coils for heating and cooling. Most of the AHUs were installed as part of the HVAC renovation in 2001. Older units and cooling tower were installed prior to the renovation. The units are all near the end of their expected lives (typically 20 years) and are recommended for replacement in a future renovation. Due to the number of exhaust fans, not all of them were observed during the site visit.

During our site visit, filters in the roof-mounted units were noted to be in good condition. These filters were last changed in January 2020 and currently utilize MERV 8 filters. According to maintenance staff at the time of our visit, MERV 13 filters have been ordered to be installed in these units. Most classrooms and offices are conditioned by fan coil units (FCU) located above the ceiling. Outdoor air (OA) is supplied from an AHU or RTU to each FCU return duct. All rooms ventilated in this manner are equipped with a power exhauster or relief fan. All of the FCU filters visible during the site visit were noted to be very dirty and appeared to have not been replaced in many years. Occupied spaces that are not conditioned by an FCU are either ventilated via a unit

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ventilator (UV) or a single-zone RTU or AHU with supply and return connections. Throughout the building, many supply, return, and exhaust grilles were noted to be in need of cleaning.

Building Automation System Review Findings

During the review of the building's DDC system, some CO_2 sensors reported either unrealistically high values, or values below nominal outdoor levels. Both indicate failing sensors due to age. These sensors should be replaced to allow for confident use of demand-controlled ventilation (DCV). DCV should be utilized for all AHUs and RTUs that do not operate as 100% OA units and the CO_2 set point should be 600 ppm. Minimum OA damper positions should be set to 30% to ensure ventilation is provided during all occupied hours.

Exhaust fan status is not currently shown in the DDC, so it is not possible to know if there is an exhaust fan failure, remotely. At a minimum, these status points should be added and all general purpose exhaust fans should be scheduled to run constantly during occupied hours. Some temperature sensors appear to be malfunctioning due to extremely high readings. These sensors should be repaired or replaced as necessary.

Nurse's Suite

The Nurse's Office is located within a health suite that includes three offices, three exam rooms, a reception area, and a main laydown area. Office B110 has been identified as an isolation room and is equipped with a supply and return grilles as well as operable windows. The entire health suite is conditioned by three FCUs that receive ventilation air from RTU-B/3. This RTU mixes return air with outdoor and returns this air to the suite. Two other isolation rooms were also identified: Office B152, which has supply and return grilles, and Coat Room C103, which only has a supply diffuser connected to AHU-C/5. It is recommended that a HEPA-filtered negative air machine is installed in each isolation room's return duct and any supply air be sealed off to ensure a negatively pressured environment. In the case of C103, which does not have a return grille, the supply diffuser should be sealed off to create a passive isolation room appropriate for short occupation.

Recommendations

Prior to re-opening the building, it is recommended that the following measures are taken:

1. Replace filters in all FCUs.
2. Replace all AHU filters with MERV 13 filters.
3. Install a HEPA-filtered negative air machine to the room return duct (seal remaining part of return air grille). Reduce supply air to ensure a negatively pressured environment. If a HEPA filter-fan cannot be obtained, seal off the supply and return grilles to create a passive isolation room appropriate for short occupation.

4. Modify air handling equipment controls to prefer economizer function during Occupied Mode.
5. Set minimum OA airflow in each RTU and AHU to 30%. If freeze alarms are activated during cold weather, the outdoor air damper percentage may be reduced, but never closed. Other freeze protection strategies should also be in place, such as controls to open the hydronic control valve, and temporarily reduce outside air to protect the coil. The occurrence of freeze alarms should be rare, and should not be the basis of design for the outside air percentage. In summer months, humidity levels should be monitored to determine maximum OA percentage to avoid mildew and mold concerns.
6. CO2 setpoints should be set to 600 ppm to maximize outdoor air intake within unit capabilities.
7. Existing CO2, RH, and temperature sensors need to be calibrated and in some cases replaced before or early in reoccupation.
8. Alter general purpose exhaust fan controls to run continuously during occupied mode.

If the following items are not completed prior to reopening, they may be implemented while the building is occupied:

1. Consider adding to the DDC status points for all of the exhaust fans using a simple status table (a separate graphic for each fan is not needed).
2. Clean all diffusers and return grilles and associated ductwork.

As part of a future renovation, it is recommended to incorporate the following:

1. Replace aging equipment.
2. Incorporate ASHRAE-recommended Nurse's station HVAC installation, including permanent isolation room, Normal and Isolation HVAC modes and negatively pressured spaces.

Disclaimer: *This list of recommendations is intended to help minimize the potential spread of viruses and/or other biological hazards. Our recommendations reflect current best practices of the HVAC industry. There is no guarantee that any of these recommendations can or will prevent any occurrences of Covid-19 or any other airborne hazards.*

Please don't hesitate to reach out with any questions.

Sincerely,

Jennifer Thurber, PE
Project Manager

Elizabeth Landry, PE, CEM, CBCP
Vice President

Attachments:
Appendix A: Referenced Guidance Documents

c: Dr. Iline Tracey
Joseph Barbarotta
David Turner

Appendix A: Referenced Guidance Documents

The following references are cited as guidance to support school re-opening during this pandemic. It is important to note that improvements noted here are recommendations only, and not required by law.

References:

- ASHRAE Epidemic Task Force Guidance for Schools and Universities, July 15, 2020
- ASHRAE Epidemic Task Force Guidance for Healthcare, August 7, 2020
- ASHRAE Practical Guidance for Epidemic Operation of ERVs, June 9, 2020
- ASHRAE Filtration and Disinfection FAQ
- ASHRAE Position Document on Infectious Aerosols, April 14, 2020
- Boston Consulting Group, Indoor Air Safety Benchmarks, 2020
- Center for Disease Control, Considerations for Operating Schools During Covid-19, August 21, 2020
- Center for Disease Control, Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation, September 22, 2020
- Center for Disease Control, Guidelines for Environmental Infection Control, 2020
- Center for Disease Control, Preparing K-12 School Administrators for a Safe Return to School in Fall 2020, July 23, 2020
- Center for Disease Control, School Admin K12 Readiness and Planning Tool, December 9, 2020
- Connecticut Department of Health, Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic, June 22, 2020
- Connecticut State Department of Education, Adapt Advance, Achieve: CT's Plan to Learn and Grow Together, September 4, 2020
- REHVA COVID-19 Guidance Document Version 4.0, Federation of European Heating, Ventilation and Air Conditioning Associations, November 17, 2020

