Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

Jacob Hiatt Magnet School
Worcester, MA

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Worcester Public Schools

A. Preface:

Worcester Public School has as Nault Architects Inc. and their consultant Seaman Engineering Corporation (SEC) to review all of their occupied buildings and comment on existing natural and mechanical ventilation.

The first part of the report is SEC's evaluation of the existing mechanical systems.

The second part of the report is an evaluation of the natural ventilation. The Building Code requires ventilation of each occupied space and that can be achieved either through mechanical of natural ventilation methods. If the natural ventilation path is chosen, there must be a clear opening(s) in the space that meet or exceed the 4% of the total room square footage. After the field survey of each room / window type was complete, the ventilation information was added to a spread sheet for calculation of the 4% and color-coding. The calculations were also color-coded on a floor plans of the building for a better overall understanding of the existing conditions.

The natural ventilation color-coding (on the spreadsheet and plans) is as follows:

- **Green Spaces**: meets or exceed the code minimum natural ventilation.
- **Yellow Spaces**: does **not** meet the code minimum natural ventilation, but does have operable window to allow some natural ventilation.
- **Red Spaces**: does not meet the code minimum natural ventilation and does not have any operable windows.

It should be reiterated that the second part of this report is only measuring natural ventilation. Therefore, newer buildings or buildings with large amounts of fixed windows may have large amounts of red and/or yellow spaces, but that doesn't mean they are not code compliant, they may be relying on mechanical ventilation. However, for this part of the report, were asked to show a baseline for all schools without mechanical equipment.

B. Building Description:

Jacob Hiatt Magnet School:

Jacob Hiatt Magnet Elementary School is located in the Doherty Quadrant of Worcester at 772 Main Street. The School was built in 1990, houses grades K-06, has 24 classrooms and the building is 50,163 square feet. The widows were replaced during a 2015 renovation.

C. Table of Contents:

1) Mechanical Ventilation Report

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I. EXECUTIVE SUMMARY

This report briefly describes the existing ventilation systems at the Jacob Hiatt Magnet School in Worcester, MA as well as their capabilities to support current code required ventilation rates. In addition, we have evaluated the systems ability to support recommendations in accordance with the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020). Several of the ASHRAE recommendations as well as those from the Harvard T.H. Chan School of Public Health and other industry sources have been presented for consideration to assist in further mitigating virus transmission through the buildings heating, ventilation, and air conditioning (HVAC) systems.

Our inspection of the existing systems was limited to visual observations coupled with review of original design drawings, when available. The findings presented in this report presume the systems are operational and delivering air quantities indicated on the original design drawings. Proper operational testing of each piece of equipment and airflow measuring would be required to confirm such operation.

During, our visual inspection we also took several spot measurements of air quality in various locations throughout the school. Measurements taken were limited to Temperature (°F), Relative Humidity (% RH), CO_2 (carbon dioxide in ppm), CH_2O (formaldehyde in ppm) and Total Volatile Organic Compounds (TVOC in ppm).

The results of the readings taken during our inspection were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

COVID-19 Control Measures:

In line with the current American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) and those from the Harvard T.H. Chan School of Public Health - 5-Step Guide to Checking Ventilation Rates in Classrooms, as well as other industry recommendations the following HVAC COVID Control Measures (CCM's) are presented for consideration to assist in mitigating virus transmission thru the HVAC systems. The following descriptions are abbreviated with additional detail found later within the report.

As of the writing of this report, the city of Worcester Public Schools (WPS) has already begun implementation of several of the measures noted below. For enhanced measures, WPS has begun to incorporate Bipolar Ionization (see ECCM-#3) extensively throughout the Jacob Hiatt Magnet School to address the current pandemic condition.

<u>CCM #1 – Pre & Post Purge Ventilation</u> – Pre- and post-purge ventilation of occupiable spaces using outside air introduced thru the HVAC systems for an extended period of time prior to and after occupancy.

Most of the HVAC systems supporting the Jacob Hiatt Magnet School are capable of implementing this measure.

<u>CCM #2 – Increased Ventilation</u> - Increase the quantity of outdoor air ventilation for improved space dilution where systems allow. Disable demand ventilation reset. The Harvard T.H. Chan School of Public Health identifies 3 outdoor air changes per hour (ACH) as the "bare minimum" during a pandemic condition.

The HVAC systems supporting the Jacob Hiatt Magnet School are supplying below the 3 ACH requirement (2+/- ACH) but can be made capable of increasing outdoor air to some extent subject to outdoor ambient conditions and equipment limitations. For the two (2) RTU's serving most of the building's spaces, more extensive control related work shall be required as described later in this report to accomplish this CCM as the units are limited to some extent by a factory controller. There are no existing HVAC drawings available for RTU-2 serving the North end of the building so we could not calculate air changes for that system however common recommendations for RTU-1 & 2 apply as they are of similar configuration and vintage.

<u>CCM #3 – Improved Filtration</u> - Improve filtration to up to MERV-13 or higher on recirculating air handling systems which can support such filtration.

Except for the fan power VAV terminals and smaller fan coil systems, the main RTU systems supporting the building appear to be capable of supporting increased filtration up to a maximum of MERV 13. At least one unit has MERV 8 pre-filters as well as final bag filters of unknown MERV rating. Systems must be tested and adjusted to accommodate the pressure drop associated with the increased filter efficiency as applicable.

In addition to the above suggested measures, we have also presented Enhanced HVAC COVID-19 Control Measures (ECCM) which could be considered for implementation. Where the above CCM's cannot be employed, one or more of the ECCM measures outlined herein may be utilized to improve indoor air quality. The following descriptions are abbreviated with additional detail found later within the report.

<u>ECCM #1: Portable Room Purifiers</u> - Portable room air purifiers could be used in select areas to help clean the air within that space. These can be especially helpful where rooms have low outdoor air changes per hour and cannot be supplied with additional outdoor air or improved system ventilation.

<u>ECCM #2: UV-C Light Sterilization</u> - UV-C lights could be considered for insertion in equipment and ductwork to help neutralize viruses as it is exposed to the light.

<u>ECCM #3: Bipolar Ionization</u> – Air ionizers may be installed in air handling systems or portable units installed in rooms to improve indoor air quality. These systems cause particles and airborne contaminants to bind together thereby increasing their size, so they tend to either drop out of the breathing zone or be better removed by air filtration. Recent studies have also shown Bipolar Ionization may inhibit the COVID-19 virus's ability to infect.

WPS has begun to incorporate Bipolar Ionization extensively throughout the Jacob Hiatt Magnet School to address the current pandemic condition.

Recommendations Summary:

Based on our site inspections, sample air quality readings and review of original drawings we found that a majority of the occupied areas of the Jacob Hiatt Magnet School comply with current ventilation codes with few exceptions noted herein. However, in order to address the pandemic level conditions currently in place the following table summarizes our recommendations, several of which, align with the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) as well as those from the Harvard T.H. Chan School of Public Health.

WPS has already begun to incorporate Bipolar Ionization (ECCM-#3) extensively throughout the Jacob Hiatt Magnet School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	Packaged Rooftop Mixed Air Systems	CCM - #1, #2 & #3 ECCM - #1 or #3 (*see note below)
Art Classroom	Packaged Rooftop Mixed Air Systems	Pending confirmation of system and air testing increase O.A. ventilation to code minimum (may require system work). CCM - #1, #2 & #3 ECCM - #1 or #3 (*see note below)
Library	Packaged Rooftop Mixed Air System	CCM - #1, #2 & #3 ECCM - #1 or #3 (*see note below)
Multi-Purpose Room	Packaged Rooftop Mixed Air System	CCM - #1, #2 & #3 ECCM - #3
Admin. & Guidance Office	Packaged Rooftop Mixed Air Systems	CCM - #1, #2 & #3 ECCM - #1 or #3 (*see note below)

*<u>Note</u>: *For individual classrooms and other areas noted, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization, are noted as possible options to improve air cleaning and changeover during pandemic conditions.*

Inevitably, during a pandemic, the best approach is a multi-faceted one which should include the above HVAC strategies as well as proper housekeeping (cleaning of spaces and surfaces), occupant actions (hand cleaning, wearing masks, social distancing, following recommended CDC guidelines) and other mitigation strategies.

II. HVAC VENTILATION ASSESSMENT

A. GENERAL

Over the last several weeks we performed site inspections of the existing school building to assess the ventilation systems in place. Manufacturer and model information was obtained from the existing ventilation equipment, when available/accessible, and visual conditions were noted.

For our review, original design drawings as well as drawings of various modifications over the years for the school were received from school facilities. In addition, we have also received and reviewed the available HVAC control drawings to ascertain current control configuration. We have used these documents to ascertain the original design ventilation rates so as to compare them to current ventilation codes and standards.

Our inspection was limited to visual assessment of systems and did not include operational testing of each piece of equipment or airflow measuring. We have however, taken some spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO_2 (carbon dioxide in ppm)
- CH_2O (formaldehyde in ppm)
- Total Volatile Organic Compounds (TVOC in ppm)

These readings were taken at a specific moment in time and may vary during the day based on space occupancy, use and activities as well as the operational state of the HVAC systems. For example, most all spaces surveyed were unoccupied or very lightly occupied and as such most all CO_2 levels were low since space CO_2 is primarily generated by occupants.

TVOC's sources can vary widely and include but are not limited to paints, finishes, adhesives, cigarette smoke, pesticides, personal care products, car exhaust, new furnishings, wall coverings, cleansers, and cooking fuels. The meter used included the following chemicals in its TVOC analysis: Acetone, Ethylene Glycol, Formaldehyde, Xylene, 1,3-Butadiene, Tetrachloroethene, Hydrogen Sulfide, Ammonia, Toluene, Benzene, Methylene Chloride, Perchloroethylene, and MTBE. The meter cannot read every possible VOC nor quantify percentages of various VOC's. In addition, we did notice the TVOC readings tended to drift up during the study, possibly due to a calibration issue, as such, the readings in this report were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

The report ventilation calculations presume, the existing systems are operating to the levels reflected on the original design drawings. Testing and Balancing by a certified balancer would be required to confirm actual airflows.

For ventilation calculations, data from current codes including the International Mechanical Code (IMC) 2015 and ASHRAE 62.1-Ventilation for Acceptable Indoor Air Quality were used. The outdoor airflow values have been corrected to adjust for the distribution systems ability to get the outdoor air to the space breathing zone with the breathing zone being within 6 feet of the occupied floor. This correction factor also known as the Zone Air Distribution Effectiveness (ZDE), varies based on how and where the air is introduced and removed from the room as well as the temperature of the air entering the room. Some examples of ZDE for various systems are as follows:

Distribution Configuration	ZDE
Ceiling supply of cool air (air below room temp.)	1.0
Ceiling supply of warm air & floor return	1.0
Clg. supply of warm Air >15F above space temp. & clg. return	0.8
Floor supply of warm air & floor return	1.0
Floor supply of warm air & ceiling return	0.7
Displacement cooling floor supply & ceiling return	1.2

For example, a displacement cooling system with a ZDE of 1.2 would require 17% (1.0 / 1.2) less outside air to properly ventilate a space than a system with warm air supplied at the ceiling level being that the displacement system is more effective in getting the outdoor air into the breathing zone. A room with a ZDE of 0.8 would require 25% (1.0 / 1.2) more outdoor air to comply with ventilation standards.

This report contains a brief description of the types of ventilation systems serving the building as well as makes recommendations, where applicable, to improve ventilation of area served by these systems. Our evaluation considered the recommendations made by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) as well as those from the Harvard T.H. Chan School of Public Health and other industry sources. All to assist in further mitigating virus transmission through the buildings heating, ventilation, and air conditioning (HVAC) systems.

B. EVALUATION

The following evaluation is based on visual observation of systems and equipment and excludes any operational testing which we understand is on-going by WPS. Evaluation includes information obtained from Worcester Public Schools on current air filters as well as existing building mechanical plans when available. In some cases, equipment was not accessible, and assessment was based only on original design drawings where available.

General Classrooms:

A majority of the classrooms in the building are heated, ventilated and cooled via two (2) packaged variable air volume (VAV) rooftop units. These units consist of air-cooled DX condensers supporting DX cooling coils, exhaust and mixing dampers, hot water coils and supply fans. Hot water is fed to all these units from the building's central boiler plant. The units are fitted with 2" thick MERV 8 filters and a bag filter of unknow MERV rating.

These RTU systems appear to be capable of supporting filtration of up to a maximum of MERV 13 (see CCM-#3) and may be at this level already with the bag filters. Systems must be tested and adjusted to accommodate the added pressure drop associated with this increased filter efficiency.

Each of the classroom air handlers deliver conditioned air to the classroom and associated spaces via a ducted supply air system and a partially ducted plenum return air system. The supply air to each classroom runs through either a VAV terminal or fan powered FVAV terminal fitted with damper operators, parallel type fans for FVAV's and hot water coils for control of primary air and temperature of air delivered to the space they serve. The fan powered VAV's have 1" thick filters with an estimated MERV rating of 7 or 8. These units can support a maximum filter rating of MERV 8. A DDC space thermostat controls the operation of the VAV damper, FVAV motor and the hydronic heating valve.

As these are mixed air systems, the amount of outdoor air delivered to each space varies based on the amount of primary air being introduced through the respective VAV & FVAV terminal. According to the design drawings for RTU-1 (no drawings available for RTU-2 serving North end of structure) the percentage of outdoor air is approximately 30% of the design supply air.

For a standard classroom, current code would require 10 CFM per person of outside air plus 0.12 CFM per SF. The zone air distribution effectiveness for the classrooms varies from 1.0 to 0.8 with the lower factor due to the presence of ceiling supply and return terminals coupled with air that may be warmer than 15°F above space in certain areas such as those spaces with greater thermal heat loss. As such, an average classroom of 800 SF with 26 occupants (25 students + 1 teacher) would require 445 CFM inclusive of the 0.8 correction or 356 CFM with the 1.0 factor.

As noted previously most of the classrooms are supported from a VAV system with parallel style FVAV terminals. These terminals deliver a maximum total and primary airflow which varies by classroom from approximately 600 to 900 CFM +/-. Based on the supporting RTU systems having 30% outside air, per design, this would yield a maximum outdoor air rate of between 200 and 270 CFM of outside air to the classroom. This amount is below the code minimum required outdoor air of 356 CFM to 445 CFM depending on space size, occupancy, and air distribution effectiveness. In addition, this deficiency becomes worse when the primary air reduces which, it would for a typical VAV terminal hence, the percentage of outdoor air would drop thereby leading to under ventilation of the space. For example, the old HVAC drawings reflect a VAV terminal primary air minimum of 50% of design which would result in a reduction of approx. 50% of the required outdoor air presuming a room is fully occupied. Increase of these minimums and/or override of minimums based on space CO_2 as well as possibly increasing RTU outdoor air would improve ventilation to spaces served by these types of systems.

Current mechanical code would require VAV systems such as this to have the ability to maintain the outdoor air volume constant across the unit's variable supply airflow operation. For example, if the unit provided 30% outside air at full airflow such as the two (2) RTU VAV units do, if the units total airflow dropped to 50%, the outdoor airflow quantity should remain constant thereby making the outdoor air percentage 60%. This would help maintain proper outdoor airflow to the various spaces as there VAV terminals vary. Based on the current control drawings and sequence of operation, the existing units do not operate in this fashion and do not monitor the amount of outdoor air the units are introducing.

In addition, these types of multi-zone VAV systems generally require a higher percentage of outdoor air to achieve compliance with current code and ASHRAE 62.1-Ventilation for Acceptable Indoor Air Quality standards. These standards factor in the individual ventilation needs of various spaces in a multi-zone system as well as the respective VAV terminals minimum and maximum ranges.

<u>Art Rooms</u>:

The art room are supported by the same central RTU unit as the normal classrooms. The current art room is approx. 735 SF in size and is supplied by air from the central VAV system. There are no existing drawings of this portion of the building however, it appears the room has not been treated different from any other classroom space.

Per the current code, art rooms require higher ventilation levels than general use classrooms at 0.7 CFM/SF of exhaust. We did not notice dedicated exhaust to this classroom to support this ventilation rate.

<u>Cafeteria, Multi-purpose & Offices</u>:

The cafeteria, multi-purpose room & Offices are supported by the same central RTU units which support the classroom spaces.

All these spaces are supported with either VAV and/or FVAV terminals. These VAV and FVAV terminals are fitted with damper operators, series fans for FVAV's and hot water coils for control of primary air and temperature of air delivered to the space they serve. The fan powered VAV's have 1" thick filters with an estimated MERV rating of 7 or 8. These units can support a maximum filter rating of MERV 8. In general, space thermostats control the operation of the VAV damper, FVAV motor and the hydronic heating valve. There is an energy management system in the building, but it appears limited to occ./unocc. control of existing systems.

As these are mixed air systems, the amount of outdoor air delivered to each space varies based on the amount of primary air being introduced through the respective VAV terminal. According to the design drawings the percentage of outdoor air from the central systems is 30% of the design supply air.

The multi-purpose room ventilation needs are similar to that for the general classrooms with 10 CFM per person and 0.12 CFM per SF. The zone air distribution effectiveness for the media center is 0.8 with the lower factor due to the presence of ceiling supply and return terminals coupled with air that may be warmer than 15°F above space temperature. With the systems delivering their current maximum outdoor airflow rate of 963 CFM the 2,098 SF space could support a maximum occupant load of 71 people. Again, this presumes the VAV terminals are 100% open and not varying which is unrealistic as such increase of these minimums and/or override of minimums based on space CO_2 as well as possibly increasing RTU outdoor air would improve the ventilation to this space.

The cafeteria space is also supported with FVAV terminals. Based on the previous noted potential issues with under-ventilation of high-density areas such as the media center and classrooms, we suspect this space may also be impacted by such. Resolutions such as increasing VAV minimums and/or override of minimums based on space CO_2 as well as possibly increasing RTU outdoor air could improve the ventilation to this space.

The office spaces are supported by FVAV terminals. In general, lower minimum primary air positions may support lower occupancy office spaces however, this can vary based on the peak design airflow to the space as well as high density areas such as conference rooms. Resolutions such as increasing VAV minimums and/or override of minimums based on space CO_2 as well as possibly increasing RTU outdoor air could improve the ventilation to these spaces.

<u>Controls</u>:

Most of the major HVAC systems supporting the school are controlled by a building energy management system (EMS). The EMS system was installed and is currently supported by Automated Logic. It appears the system controls the rooftop units and the boiler plant but with limited to occ./unocc. control of the RTU's. The two (2) packaged RTU units have factory furnished controls which control much of their internal operation with the EMS commanding occupied, unoccupied modes.

The operating schedule for much of the equipment is based on the school's occupancy schedule. The schedule is adjustable via the front-end computer workstation.

C. IAQ & Ventilation Summary

IAQ Summary:

During our inspection we obtained spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO_2 (carbon dioxide in ppm)
- CH_2O (formaldehyde in ppm)
- Total Volatile Organic Compounds (TVOC in ppm)

The readings were taken at a specific moment in time and may vary during the day based on space occupancy, use and activities as well as the operational state of the HVAC systems. For example, most all spaces surveyed were unoccupied or very lightly occupied and as such most all CO_2 levels were low since space CO_2 is primarily generated by occupants.

In addition, we noted some elevated TVOC levels and/or formaldehyde levels in areas which would not generally be expected to have such elevated levels. Although TVOC's (which includes formaldehyde) may come from varied sources such as cleaners, air fresheners and such, formaldehyde levels are often from off-gassing of furnishings or building materials. It is important to note that elevated levels of TVOC's may have been partially caused by recent enhanced cleaning measures or due to ventilation systems that were not in full operation at the time.

Measurements taken included space humidity. Humidity levels has been found to play a role in the controlling the spread of COVID-19. ASHRAE recommends winter humidity levels be kept between 40% to 50% and summer humidity levels between 50% and 60% with a summer target of 50%. Maintaining humidity levels within the above ranges has been found to limit the growth and transmission of certain bacteria and viruses as well as supports respiratory function. The below chart is taken from the 2020 ASHRAE Handbook – HVAC Systems and Equipment and reflects the impact of space humidity on the increase or decrease of effect on various space contaminants. This chart only reflects increase or decrease of effect from humidity and does not intend to imply that there is zero growth or impact of a certain contaminant when the sloped bar graph zero's out.

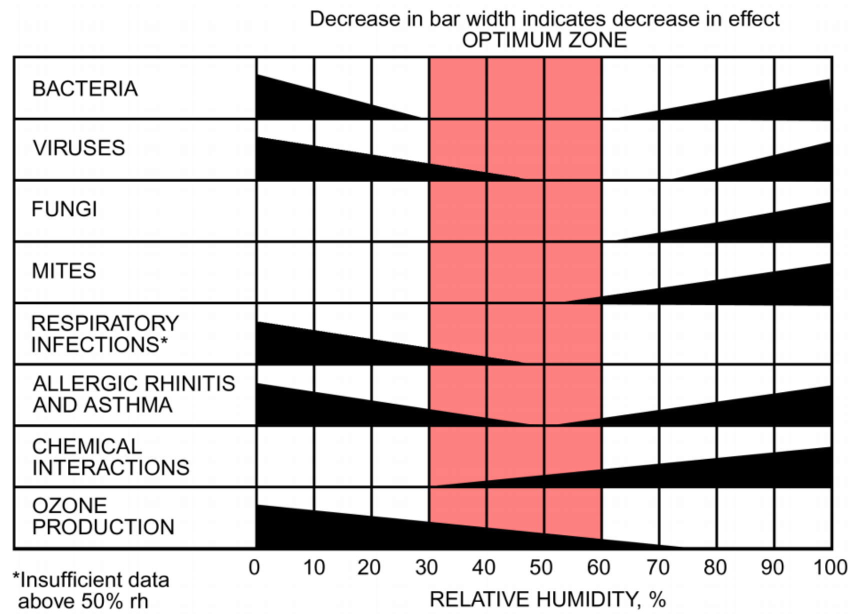

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The Jacob Hiatt Magnet School HVAC systems have no active humidity control.

Space dehumidification is limited only to those areas which have air conditioning cooling. However, this dehumidification is not actively controlled by a humidity setpoint. Moisture removal only occurs when these systems are operating in the cooling mode. As such, space humidity may climb above 60% during periods when low thermal loads require less cooling (i.e., a cool damp day) or swing above and below 60% as the systems cycle based on space temperature.

Caution must be taken when considering adding active humidification to existing buildings as it is imperative that the buildings thermal envelope and vapor barriers be reviewed. Although newer structures, such as Jacob Hiatt Magnet School often have a fair vapor barrier the varying wall and window construction and thermal characteristics may limit the ability for active humidification. Adding humidity in the wintertime without consideration of the building construction could result in moisture condensation on windows and within wall assemblies which may create a damaging and unhealthy condition for the building and its occupants. Review of the building envelope should take place prior to consideration of the addition of any humidification system. As such, our recommendations contained with this report exclude active humidification control until such time as the envelope can be reviewed.

The IAQ readings taken during the time of the inspection are contained within the table below. In addition, the table reflects the outdoor air exchange rate in the rooms based on design data from existing plans.

The document entitled "5-Step Guide to Checking Ventilation Rates in Classrooms" from the Harvard T.H. Chan School of Public Health recommends a target outdoor air exchange rate during these pandemic conditions. The document identifies 5 air changes per hour (ACH) and above as "excellent" down to a 3 ACH being considered "bare minimum". Many of the general classrooms in the Jacob Hiatt Magnet School have a design outdoor air exchange rate of below 3 (2+/- ACH). When the outdoor air exchange rate is lower than the target 5 ACH, the document recommends the following strategies:

1. Increase outdoor air (see CCM #2)
2. Use MERV 13 filters (or greater) on recirculated air (see CCM #3)
3. Add portable air cleaners with HEPA filters to the classroom (see ECCM #1)

It should be made clear however, that a room that has less that what this document considers the bare minimum outdoor air exchange rate may meet or exceed the most current ventilation standards and therefore is not under ventilated. The 5 ACH or greater recommendation is meant to address the pandemic conditions being experienced as this level of ACH would equate to nearly 100% outside air requirement for a conventional mixed air cooling & heating system.

The following tables describe areas and systems where the above measures as well as others presented in this report may be applied.

Jacob Hiatt Magnet School IAQ Sampling Summary

Space Tested	Temp. °F	Humidity % RH	CO2 %	TVOC ppm	HCHO ppm	Room Area SqFt	Room Ht. Ft	Volume Cubic Feet	Original Design OA CFM	Original OA Air ACH	Notes
Sub Basement											
Computers SB01A	71.3	31.7	430	0.78	0.07	1190	11.58	13780	na	na	a
Basement											
Waiting B26	70.2	33.6	463	0.94	0.11	355	7.91	2808	140	3	
Science Rm B28	71.2	32.1	572	1.3	0.11	771	11.25	8674	609	4.2	
Pre School B11	71.2	30.9	438	0.93	0.11	674	11.25	7583	200	1.6	
Cafetorium B04	72.4	31.7	435	0.78	0.08	1787	8.41	15029	na	na	a
1st Floor											
Kindergarten 104	72.6	33.3	456	0.77	0.08	1241	8.58	10648	na	na	a
Kindergarten 108	75.1	32.9	491	1.07	0.1	1177	8.16	9604	287	1.8	
Nurse 111	73.8	33.6	482	0.89	0.1	106	7.91	838	33	2.4	
Classroom 118	71.1	34.8	462	1.08	0.09	869	8.25	7169	426	3.6	
Lobby 120	75.7	33.7	516	1.18	0.09	352	7.08	2492	446	10.7	
2nd Floor											
Primary Special Ed 204	72.3	35	509	0.57	0.04	628	7.91	4967	na	na	a
Classroom 210	73.1	34.3	485	0.38	0.06	705	10.16	7163	177	1.5	
Multi-Purpose Rm 218	74.2	33.7	492	0.61	0.08	2098	20.16	42296	963	1.4	
3rd Floor											
Library Media 302	71.2	24.3	433	1.4	0.05	1602	7.75	12416	na	na	a
Art Room 306	72.1	30.2	491	1.25	0.07	735	7.08	5204	na	na	a
Classroom 308	73.9	32.7	486	1.18	0.14	715	9.58	6850	205	1.8	
Intermediate Special ED 315	75.1	33.1	488	0.99	0.12	713	9.58	6831	291	2.6	

IAQ Summary Table Notes:

TVOC Note: As noted previously, the TVOC readings tended to drift up during the study, possibly due to a calibration issue, as such, the readings in this report were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

a. *There are no HVAC plans for the North areas of the building served by RTU-2 hence OA data is not presented.*

Ventilation System Summary & Recommendations:

The following table is based on original design drawings and reflect most of the systems which provide ventilation air to the building. The units ID tag, area served, ventilation data and filter efficiencies are listed. The table also reflects possible COVID Control Measures (CCM) and Enhanced COVID Control Measures (ECCM) described later in this report which may apply to such systems to improve performance either during pandemic conditions and/or post pandemic conditions.

Jacob Hiatt School Ventilation System Summary

Unit ID	Area Served	Exist. Supply CFM	Exist. O.A. CFM	Exist. O.A. %	Exist. Filter Qty & Size	Exist. Filter MERV Rating	Exist. Filter Vel. (FPM)	Proposed CCM #	Proposed ECCM #	Notes
RTU-1	South Building	23,000	6,900	30	MERV 8 Pre & Bag Fil. MERV ? Final	13 est.		1, 2	1, 3	a, b
RTU-2	North Building	30,000 est.	9,000 est.	30	MERV 8 Pre & Bag Fil. MERV ? Final	13 est.		1, 2	1, 3	a, b

Ventilation System Summary Notes:

a. *To improve the ventilation effectiveness and outdoor airflow control of the classroom systems we would recommend airflow stations be added to the supply fan, outdoor airflow, and exhaust airflow of each of the two (2) RTU units along with associated control improvements.*

b. *For individual classrooms and other areas noted, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization, are noted as possible options to improve air cleaning and changeover during pandemic conditions.*

II. COVID-19 HVAC MITIGATION MEASURES

A. HVAC COVID-19 CONTROL MEASURES

In line with the current American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) and those from the Harvard T.H. Chan School of Public Health - 5-Step Guide to Checking Ventilation Rates in Classrooms, as well as other industry recommendations the following HVAC COVID Control Measures (CCM's) are presented for consideration to assist in mitigating virus transmission thru the HVAC systems.

The ASHRAE Epidemic Task Force recommends several measures to assist in COVID-19 mitigation with more aggressive action with epidemic conditions in place (ECiP) and post-epidemic conditions in place (P-ECiP). For ECiP conditions in place the HVAC COVID-19 Control Measures (CCM) that could be readily applied to the Jacob Hiatt Magnet School surveyed are outline herein. Refer to the Ventilation System Summary Table for applicable CCM recommendations.

It is imperative that all systems be maintained and checked to confirm proper operation in line with their original design, adjusted where applicable, as described herein. In addition, a Testing and Balancing company should be enlisted to adjust and confirm all systems are properly achieving their design outdoor air, supply air and exhaust air levels.

CCM #1 – Pre & Post Purge

Pre- and post-purge ventilation of occupiable spaces using outside air introduced the HVAC systems. This would be accomplished by starting the ventilation systems in occupied mode (i.e., OA at design or higher) 4 hours prior to schedule building occupancy and maintain the occupied mode for 4-hours after occupancy ends.

Most of the HVAC systems supporting the Jacob Hiatt Magnet School are capable of implementing this measure.

CCM #2 – Increased Ventilation

Increase outdoor air ventilation for improved space dilution where systems allow. This would entail increasing the minimum outdoor air damper positions on all mixed air style systems within the limits of the equipment capacity and overriding any demand ventilation reset schemes (i.e., CO_2 reset). A control sequence would need to be implemented for the respective air handlers which would limit the outdoor air volume to the unit's respective capability such that proper control of the discharge air can be maintained as well as freeze protection of coils. In addition, sequence would need to include limitation based on boiler plant and cooling system capabilities and summertime moisture limitations. For buildings which have anti-freeze in water-based heating and/or cooling systems, concern of unitary coil freeze up is reduced.

The HVAC systems supporting the Jacob Hiatt Magnet School are capable of implementing this measure subject to outdoor ambient conditions and equipment limitations. For the two (2) RTU's serving most of the building's classroom spaces, more extensive control related work shall be required as described later in this report to accomplish this CCM as the units are limited to some extent by a factory controller. Existing VAV and FVAV controls may also require upgrade.

CCM #3 – Improved Filtration

Improve filtration to up to MERV-13 on air handling systems, especially those which recirculate air. In addition, if possible, as filters are replaced provide sealant or gasketing between and/or around filters to reduced air bypass around filter sections.

Except for the fan power VAV terminals which are limited to filters not in excess of MERV 8 the main air handling RTU systems appear to be capable of supporting increased filtration up to a maximum of MERV 13. Existing bag filters may already achieve this filtration rate but should be verified.

B. ENHANCED HVAC COVID-19 CONTROL MEASURES

In addition to the suggested above measures below are some Enhanced HVAC COVID-19 Control Measures (ECCM) which could be considered for implementation. Refer to the Ventilation System Summary Table under the respective schools for applicable recommendations.

ECCM #1: Portable Room Purifiers

Portable room air purifiers could be used in select areas to help clean the air within that space. These could be applied in areas such as those where the population is in a higher risk group of developing COVID-19 complications or anywhere where real time space cleaning is required. Products which include HEPA filters and fans with air exchange rate appropriate for the size room should be selected.

ECCM #2: UV-C Light Sterilization

UV-C lights can be inserted in equipment and ductwork to help neutralize viruses as it is exposed to the light. UV technology has been studied and used extensively, primarily in hospital settings for virus and bacteria control and in the general HVAC primarily to prevent build-up on coils. To properly mitigate the virus an extended run of return air duct would need to be identified to allow for adequate exposure to UV-C light since a light bar just at the unit coil or filter will primarily just prevent build-up of mold, bacteria, and viruses on those surfaces.

ECCM #3: Bi-Polar Ionization

Air ionizers are meant to be installed in the supply air duct or plenum downstream of fans and filters. They are also offered as portable units for room application. In Jacob Hiatt Magnet Schools case they could be installed in the supply air duct of the respective mixed air handling systems. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Jacob Hiatt Magnet School to address the current pandemic condition.

Air ionizers appear to be showing quite a bit of promise for low system impact in retrofit application. For years, these products have been used to primarily clean air of dust and particles by forcing the particles to bind together and either drop out of the breathing zone and/or better be able to be captured by HVAC system air filters by making particles larger. Recently, there are studies which claim to show the ionizers work on neutralizing virus's in the space prior to needing to draw these pollutants back to the units where filters and/or other cleaning technology such as UV-C could occur.

ASHRAE has not taken a definitive stance on Bipolar Ionization with regard to virus mitigation as of yet and has deferred to CDC's comment that it is still considered an emerging technology in this regard. Bipolar Ionization has been used for decades primarily for the removal of particles within the air. During that period, its use was focused more on facilities such as convention centers, casinos, and the like as there are large amounts of occupant and activity generated pollutants. Only recently has Bipolar Ionization been looked at for virus mitigation which is why ASHRAE and CDC still view it as an emerging technology being that there are not extensive 3rd party studies and reviews of its capability in this regard.

That said, even ignoring its potential virus neutralizing capabilities, the ability of the product to bind smaller particles into larger particles results in an overall desirable indoor air quality benefit in that it increases the capabilities of air filters to filter the air as well as promotes particles to drop out of the breathing zone. We do, however, recommend the technology be provided on systems that meet code required outdoor air ventilation levels as this technology is not a replacement for outdoor air.

Inevitably, during an epidemic, the best approach is a multi-faceted one and should include the above HVAC strategies as well as proper housekeeping (cleaning of spaces and surfaces), occupant actions (hand cleaning, wearing masks, social distancing, following recommended CDC guidelines) and other mitigation strategies.

2) Natural Ventilation Summary

Jacob Hiatt Magnet School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	Number of windows by Type				Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
				A AWNING	1.67	B AWNING	1.83				
Sub-Baasement											
SB 01A - Computer	classroom	1190	47.6					0.00	47.60	NO	
SB01B - Activiites	classroom	1056	42.24					0.00	42.24	NO	
Basement											
B01 - Women	toilet	200	8					0.00	8.00	NO	
B02 - Men	toilet	198	7.92					0.00	7.92	NO	
B03	classroom	406	16.24				3	5.50	10.74	NO	
B04 - Cafeteria	café	1787	71.48				5	9.17	62.31	NO	
B05 - Teacher's Dinning	café	500	20				4	7.33	12.67	NO	
B06 - Kitchen	café	507	20.28					0.00	20.28	NO	
B06A - Toilet	toilet	31	1.24					0.00	1.24	NO	
B08	classroom	666	26.64					0.00	26.64	NO	
B09 - Storage	storage	51	2.04					0.00	2.04	NO	
B10 - Toilet	toilet	50	2					0.00	2.00	NO	
B11	classroom	674	26.96					0.00	26.96	NO	
B12 - Toilet	toilet	50	2					0.00	2.00	NO	
B13 - Storage	storage	51	2.04					0.00	2.04	NO	
B15 - Storage	storage	231	9.24					0.00	9.24	NO	
B15A - Custodian	support	88	3.52					0.00	3.52	NO	
B15B - Kit Storage	storage	98	3.92					0.00	3.92	NO	
B17 - Boys Room	toilet	103	4.12					0.00	4.12	NO	
B18 - Storage	storage	103	4.12					0.00	4.12	NO	
B19 - Janitor	support	17	0.68					0.00	0.68	NO	
B21 - Office	office	113	4.52					0.00	4.52	NO	
B22 - Main Office	office	355	14.2					0.00	14.20	NO	
B23 - Toilet	toilet	37	1.48					0.00	1.48	NO	
B24 - Conference	conference	394	15.76		1			1.67	14.09	NO	
B25 - Office	office	121	4.84					0.00	4.84	NO	
B28 - Classroom	classroom	771	30.84		2			3.33	27.51	NO	
First Floor											
102	classroom	1241	49.64				6	11.00	38.64	NO	
103 - Toilet	toilet	51	2.04					0.00	2.04	NO	
104	classroom	1186	47.44				6	11.00	36.44	NO	
105 - Toilet	toilet	51	2.04					0.00	2.04	NO	
106 - Guidance	office	1241	49.64					0.00	49.64	NO	
107A	classroom	250	10					0.00	10.00	NO	
107B	classroom	390	15.6					0.00	15.60	NO	
108	classroom	1177	47.08					0.00	47.08	NO	
108A - Toilet	toilet	53	2.12					0.00	2.12	NO	
109 - Toilet	toilet	50	2					0.00	2.00	NO	
111 - Nurse	support	106	4.24					0.00	4.24	NO	
112 - Exam	support	102	4.08					0.00	4.08	NO	
114 - Office	office	52	2.08					0.00	2.08	NO	
114 - Toilet	toilet	50	2					0.00	2.00	NO	
115 - Girl's Room	toilet	101	4.04					0.00	4.04	NO	
116 - Janitor	support	26	1.04					0.00	1.04	NO	
117 - Boy's Room	toilet	99	3.96					0.00	3.96	NO	
118	classroom	867	34.68		5			8.33	26.35	NO	
119	classroom	869	34.76		4			6.67	28.09	NO	
120 - Lobby	entry	352	14.08					0.00	14.08	NO	
121 - Vestibule	entry	37	1.48					0.00	1.48	NO	
122 - Storage	storage	76	3.04					0.00	3.04	NO	
123 - Storage	storage	76	3.04					0.00	3.04	NO	
124	classroom	972	38.88					0.00	38.88	NO	

Second Floor

202	classroom	649	25.96				3	5.50	20.46	NO	
203	classroom	649	25.96				3	5.50	20.46	NO	
204	classroom	628	25.12				3	5.50	19.62	NO	
205	classroom	619	24.76				3	5.50	19.26	NO	
206 - Waiting	office	94	3.76					0.00	3.76	NO	
207 - Office	office	148	5.92					0.00	5.92	NO	
208	classroom	744	29.76					0.00	29.76	NO	
209	classroom	645	25.8					0.00	25.80	NO	
210	classroom	705	28.2					0.00	28.20	NO	
212 - Boy's Room	toilet	175	7					0.00	7.00	NO	
213 - Girl's Room	toilet	200	8					0.00	8.00	NO	
215	classroom	648	25.92		2			3.33	22.59	NO	
216	classroom	709	28.36		2			3.33	25.03	NO	
217	classroom	651	26.04		2			3.33	22.71	NO	
218 - Multi-Purpose Room	conference	2098	83.92					0.00	83.92	NO	

Third Floor

302 - Library / Media	classroom	1602	64.08				5	9.17	54.91	NO	
303 - Office	office	88	3.52					0.00	3.52	NO	
304	classroom	675	27				3	5.50	21.50	NO	
305 - Office	office	339	13.56					0.00	13.56	NO	
306 - Art Room	classroom	735	29.4					0.00	29.40	NO	
307	classroom	651	26.04					0.00	26.04	NO	
308	classroom	715	28.6					0.00	28.60	NO	
310 - Boys Room	toilet	187	7.48					0.00	7.48	NO	
311 - Girl's Room	toilet	195	7.8					0.00	7.80	NO	
312 - Janitor's Room	support	114	4.56					0.00	4.56	NO	
314	classroom	587	23.48					0.00	23.48	NO	
315	classroom	713	28.52					0.00	28.52	NO	
316	classroom	649	25.96					0.00	25.96	NO	
317 - Walkway	entry	768	30.72					0.00	30.72	NO	

Window Type	Width	Hieght	Projection	Venting
A - Hopper	36	24	4	1.67
B - Hopper	42	24	4	1.83

Room Color Key	
(green)	Rooms that meet or exceed the minimum code required ventilation
(yellow)	Rooms that do not meet the code required ventilation, but have operable windows.
(red)	Rooms that do not have operable windows (either fixed or none present)