Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

Worcester Arts 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:

Worcester Arts Magnet School:
Worcester Arts Magnet School is located in the Burncoat Quadrant of Worcester at 315 St. Nicholas Ave. The School was built in 1961, houses grades PK-06, has 21 classrooms and the building is 55,284 square feet. The windows are original to the 1961 construction.

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 Worcester Arts 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 however, for Worcester Arts Magnet school no design drawings existed. 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 where possible. For enhanced measures WPS has begun to incorporate Bipolar Ionization (see ECCM-#3) extensively throughout the Worcester Arts Magnet School to address the current pandemic condition.

CCM #1 – Pre & Post Purge Ventilation - 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.

The building has a mix of HVAC system types many of which appear to be capable of implementing this measure.

CCM #2 – Increased Ventilation - 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 building has a mix of HVAC system types many of which appear to be capable of implementing this measure.

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

The unit ventilators in the school will not support increased filtration above MERV 8 either due to physical equipment limitations (i.e., unit ventilators limited to 1" filters) or due to fan capacity limitations. The air handling systems serving the gymnasium are old and may not be capable of supporting increased filter efficiency. Increased filtration efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level.

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:

ECCM #1: Portable Room Purifiers - Portable room air purifiers may be used in select areas and rooms to help clean the air within the room. These can be especially helpful where rooms have low outdoor air changes per hour and cannot be supplied with additional outdoor air or where existing systems cannot accommodate improved filtration.

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

ECCM #3: Bipolar Ionization - 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 Worcester Arts 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 Worcester Arts Magnet School appear to have systems with the potential to comply with current ventilation codes, pending balancing and verification, 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 Worcester Arts Magnet School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
Gymnasium	AHU-1 & AHU-2	CCM-#1 & #2 ECCM - #3
General Classrooms	Unit Ventilators	CCM - #1 & #2 ECCM - #1 & #3 (see *note below)
Offices	None	ECCM - #1 & #3 (see *note below)

**Note*: 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. Regardless, we highly recommend outdoor air of some level be provided for areas noted as having none, even if via windows as there is no substitute for proper ventilation.*

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. However, for the Worcester Arts Magnet School, no existing HVAC drawings were made available so reference only to current design criteria is made.

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, if available. 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 / 0.8) 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 & Misc. Areas:

A majority of the classrooms in the building are ventilated and heated with classroom unit ventilators. The UV's are fitted with air 1" thick filters with an estimated MERV rating of 7 or 8 which is typical for units of this type. These units can support a maximum filter efficiency of MERV 8.

The rooms with classroom unit ventilators are connected to louvers along exterior walls with each having an associated control damper to allow outdoor air to enter the classroom space through the unit ventilator. Existing control drawings reflect control of these UV systems. During occupied periods, the unit fans would be configured to run continuous to provide space ventilation and electric operators modulate the steam valve, face & bypass dampers (where applicable) and mixing dampers to maintain space temperature setpoint. During unoccupied periods the fans cycle off and only cycle on with the associated heating valve opening when there is a need for heating or economizer (OA) cooling.

For a standard classroom, current code would require 10 CFM per person of outside air plus 0.12 CFM per SF. For a system with a presumed zone air distribution effectiveness of 1.0, a room size of 900 SF with 26 occupants (25 students + 1 teacher) would require 368 CFM of outdoor air. There are no existing drawings reflecting outdoor air ventilation rates however, we would expect the UV's to be capable of providing the code required outside air. Testing and balancing of these and other systems, would be required to confirm outdoor airflow rates.

Classroom exhaust appears to be accomplished via multiple rooftop exhaust fans. Bathroom and local exhaust requirements are supported by sidewall and roof mounted centrifugal exhaust fans of unknown capacity. Existing control drawings do not reflect control of these fans, so their operational status is unknown.

Gymnasium:

The gymnasium is supported by two (2) air handling units. The units deliver air to the space via a ducted supply and return system. The volume of outdoor air the system moves is unknown and would need to be determined thru testing and balancing.

The units are mixed air systems each configured with mixing dampers, filter sections, hot water coil and supply fan. There are no design drawings to confirm quantity of outdoor air introduced by these systems. However, the units do appear to the have the capability to introduce a fair percentage of outdoor air and should be able to provide the code required outdoor air identified below. The gymnasium AHU's have controls which include occupancy sensors which should be disabled during pandemic conditions to insure good pre- and post-purge air ventilation.

The units have 2" thick pleated filters with an estimated MERV rating of 8. Due to the systems age we suspect the unit cannot support filtration above MERV 8. Increased filtration efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level.

The current code requires 0.3 CFM per SF of outdoor air for play area coupled with a separate value for spectator area. As the bleachers were retracted during our visit, the spectator area capacity is unknown. However, if we presume the entire space as play area, the required outdoor air volume for the 5,120 SF space is 1,920 CFM using a ZDE of 0.8 due to the high supply and return air duct configuration.

Science & Art Rooms:

There are no assigned science rooms, and one art room is indicated on the plans. The art room is serviced by the same UV type systems as the current classrooms.

Per the current code, science rooms and art rooms require higher ventilation levels than general use classrooms with a driving factor being required exhaust air. For science laboratories 1 CFM per SF of exhaust is required and for art rooms 0.7 CFM of exhaust is required along with the associated make-up air. Added exhaust and associated make-up air may be required for this room to support this requirement.

Office:

The office areas do not appear to have any ventilation systems except that which is provided via operable windows and local exhaust from adjoining bathrooms. Positive air ventilation should be provided in these areas.

Controls:

Controls in the building appear to be fairly comprehensive with the exception of no mention of control of exhaust fans or radiation. As a minimum, from the control drawings it appears the building energy management system (EMS) controls the unit ventilators and the gymnasium AHU units. The gymnasium system has occupancy sensors which should be disabled during pandemic conditions to insure good pre- and post-purge air ventilation.

The EMS system is currently supported by Automated Building Systems, Inc (ABS).

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.

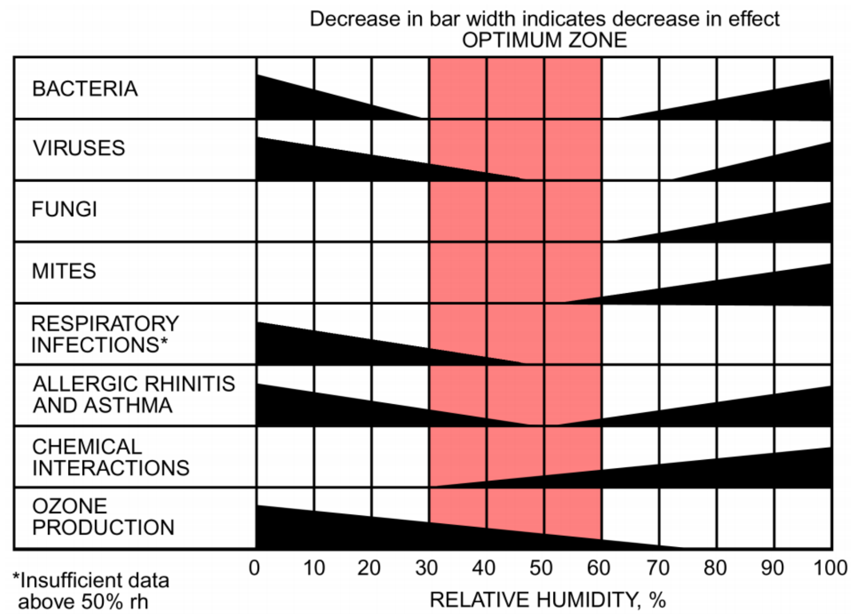

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The Worcester Arts 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. Older structures, such as Worcester Arts Magnet School often have poor 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 Worcester Arts Magnet School appear to have the ability to provide an outdoor air exchange rate of approx. 3 however, as there were no original design drawings, testing would need to occur to verify the air exchange rate. 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 dependent on the pace occupancy and therefore may not be considered under ventilated by code standards. 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.

Worcester Arts 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
1st Floor											
Boys	74.6	21.4	475	1.36	0.11	272	9	2448	N/A	N/A	
Room 5	75.5	21.1	465	1.4	0.17	844	9	7596	N/A	N/A	
Room 6	74.8	19.3	455	1.38	0.17	929	9	8361	N/A	N/A	
Multi-Purpose Room	76.8	19.2	483	1.33	0.18	2361	17	40137	N/A	N/A	
Room 1B	76.1	19.6	448	1.37	0.18	1472	8.916	13124	N/A	N/A	
Kitchen	76.2	19.1	492	1.35	0.18	168	7.916	1330	N/A	N/A	
Nurse	77.9	18.2	490	1.36	0.17	305	9.25	2821	0	0	
Main Office	78.9	19.7	517	1.38	0.17	295	9	2655	0	0	
Principals	77.3	19.8	548	1.39	0.22	194	9	1746	0	0	
Dance & Chior	73.7	20.3	445	1.32	0.13	1162	7.75	9006	N/A	N/A	
Gymnasium	72.6	21.9	451	1.33	0.11	5120	21.75	111360	N/A	N/A	
Art Room 10	71.5	23.1	466	1.32	0.19	1357	8.5	11535	N/A	N/A	
Music Room 11	73.5	18.9	451	1.37	0.11	1296	8.416	10907	N/A	N/A	
Library	74.6	21.6	452	1.37	0.12	2022	8.416	17017	N/A	N/A	
Room 19	79.1	17.8	464	1.4	0.16	932	8.5	7922	N/A	N/A	
Room 20	76.7	19.6	467	1.4	0.15	887	8.33	7389	N/A	N/A	
Room 21	80.2	18.9	470	1.42	0.17	962	8.66	8331	N/A	N/A	

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.

<u>Ventilation System Summary & Recommendations</u>:

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.

We highly recommend at least minimum outdoor air be provided in areas which do not have such systems or if existing ventilation systems are not operational. For example, office areas should be supplied with OA ventilation as none appears to exist.

Worcester Arts Magnet 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
UV	Classrooms +	N/A	N/A	N/A	varies	8	N/A	#1, #2	#1, #3	a
AHU-1 & 2	Gymnasium	N/A	N/A	N/A	N/A	8	N/A	#1, #2	#1, #3	c
	Misc.	N/A	N/A	N/A	none	N/A	N/A	N/A	#1, #3	a, b

Ventilation System Summary Notes:

a. *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.*

b. *We highly recommend outdoor air of some level be provided, even if via windows as there is no substitute for proper ventilation regardless of other measures employed.*

c. *Disable occupancy sensors to allow for pre- and post-purge ventilation.*

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 Worcester Arts 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 Worcester Arts Magnet School appear to be 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.

Most of the classroom UV systems as well as the AHU systems appear to have the ability to increase outdoor air for higher outdoor air ventilation and air exchange rate.

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.

The classroom unit ventilators and the air handlers cannot support filtration in excess of MERV 8. All replacement filters for these terminal units should meet MERV 8 requirements.

Prior to implementation of higher filtration levels in excess of MERV 8, existing equipment capabilities must be reviewed to verify it can support the added pressure drop imposed by MERV-13 filtration. Testing and balancing to confirm current airflow, pressure drops, and fan motor power coupled with manuf. published data would be required to confirm the unit's capability for improved filtration.

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 and rooms to help clean the air within the room. 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 such as the nurse's office. 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 Worcester Arts Magnet School's case they could be installed in the supply air duct of the respective mixed air handling system, in unit ventilators and portable units may be considered. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Worcester Arts 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 applications. 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 that 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 in facilities such as convention centers, airports, 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

Worcester Arts 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
				1 DBL HUNG	1.94	2 DBL HUNG	1.75				
First Floor											
D - Wing											
Room 01B (Both)	classroom	2978	119.12		9		7	29.70	89.42	NO	
Room 01B - Storage	storage	47	1.88					0.00	1.88	NO	
Kitchen	kitchen	168	6.72					0.00	6.72	NO	
Lobby / Vestibule	entry	707	28.28					0.00	28.28	NO	
Men's Room	toilet	90	3.6		1			1.94	1.66	NO	
Office	office	174	6.96		2			3.88	3.08	NO	
Spec Education	office	305	12.2		4			7.75	4.45	NO	
Staff Break Room	support	161	6.44		3			5.82	0.62	NO	
Women's Room	toilet	122	4.88					0.00	4.88	NO	
Nurse's Office (include toilet)	office	262	10.48		3			5.82	4.66	NO	
Main Office	office	286	11.44		5			9.69	1.75	NO	
Main Office - Vault	support	52	2.08					0.00	2.08	NO	
Principal's Office	office	193	7.72		3			5.82	1.90	NO	
Principal's Office - Toilet	toilet	47	1.88					0.00	1.88	NO	
Multi-Purpose Room	aud	2360	94.4		10			19.38	75.02	NO	
Multi-Purpose Room - Stage	sud	577	23.08					0.00	23.08	NO	
C - Wing											
Room 02	classroom	939	37.56		9			17.45	20.11	NO	
Supplies & Sever Room	support	313	12.52					0.00	12.52	NO	
Custodian Office	office	293	11.72					0.00	11.72	NO	
Room 03	classroom	844	33.76		8			15.51	18.25	NO	
Room 04	classroom	928	37.12		8			15.51	21.61	NO	
Room 05	classroom	844	33.76		8			15.51	18.25	NO	
Boy's Room	toilet	272	10.88		1			1.94	8.94	NO	
Girl's Room	toilet	266	10.64		1			1.94	8.70	NO	
Room 06	classroom	929	37.16		9			17.45	19.71	NO	
Room 06 / 08 - Storage	storage	61	2.44					0.00	2.44	NO	
Room 06 / 08 - Toilet	toilet	74	2.96		2			3.88	-0.92	YES	
Room 07	classroom	966	38.64		9			17.45	21.19	NO	
Room 07 / 09 - Storage	storage	81	3.24					0.00	3.24	NO	
Room 07 / 09 - Toilet	toilet	75	3		2			3.88	-0.88	YES	
Sink Room	support	14	0.56					0.00	0.56	NO	
Room 08	classroom	895	35.8		9			17.45	18.35	NO	
Room 09	classroom	921	36.84		9			17.45	19.39	NO	
B - Wing											
Room 10 - Art Room	classroom	1357	54.28				5	8.75	45.53	NO	
Room 10 - Storage	support	130	5.2					0.00	5.20	NO	
Room 11 - Music Room	classroom	1296	51.84				5	8.75	43.09	NO	
Room 11 - Storage	support	130	5.2					0.00	5.20	NO	
Room 12	classroom	297	11.88				2	3.50	8.38	NO	
Garage	support	212	8.48					0.00	8.48	NO	
Speech Language	classroom	103	4.12					0.00	4.12	NO	
Psych Office	office	102	4.08					0.00	4.08	NO	
Storage	storage	98	3.92					0.00	3.92	NO	
Sink Room	support	31	1.24					0.00	1.24	NO	
Women's Room	toilet	174	6.96					0.00	6.96	NO	
Men's Room	toilet	211	8.44					0.00	8.44	NO	
Gymnasium	gym	5120	204.8					0.00	204.80	NO	
Gym Storage	storage	71	2.84					0.00	2.84	NO	
Gym Sink	support	15	0.6					0.00	0.60	NO	
Occupational Physical Therapy	office	538	21.52					0.00	21.52	NO	
Occupational Phys. Therapy - Closet	storage	32	1.28					0.00	1.28	NO	
Gym Office	office	71	2.84					0.00	2.84	NO	
Gym Office - Shower Room	support	41	1.64					0.00	1.64	NO	
Occupational Phys. Therapy - Storage	storage	182	7.28					0.00	7.28	NO	
Occupational Phys. Therapy - Toilet	toilet	75	3					0.00	3.00	NO	
Gym Equiptment	storage	442	17.68					0.00	17.68	NO	
Dance & Chior	classroom	1161	46.44					0.00	46.44	NO	
Dance & Chior - Entry	entry	32	1.28					0.00	1.28	NO	
Drama Storage	storage	65	2.6					0.00	2.60	NO	
Drama Storage - Shower	support	41	1.64					0.00	1.64	NO	
Drama Storage - Toilet	toilet	75	3					0.00	3.00	NO	
Dance & Chior - Storage	storage	71	2.84					0.00	2.84	NO	
Dance & Chior - Sink Room	support	15	0.6					0.00	0.60	NO	
A - Wing											
Room 13	classroom	925	37				3	5.25	31.75	NO	
Room 14	classroom	893	35.72				3	5.25	30.47	NO	
Coat Room	support	136	5.44					0.00	5.44	NO	
Room 15	classroom	964	38.56				3	5.25	33.31	NO	
Room 16	classroom	961	38.44				3	5.25	33.19	NO	
Room 17	classroom	891	35.64				3	5.25	30.39	NO	
Room 18	classroom	925	37				3	5.25	31.75	NO	
Coat Room	support	136	5.44					0.00	5.44	NO	
Girl's Room	toilet	223	8.92					0.00	8.92	NO	
Office	office	128	5.12					0.00	5.12	NO	
Men's Room	toilet	52	2.08					0.00	2.08	NO	
Women's Room	toilet	52	2.08					0.00	2.08	NO	
Boy's Room	toilet	263	10.52					0.00	10.52	NO	
Room 19	classroom	932	37.28				3	5.25	32.03	NO	
Room 20	classroom	887	35.48				3	5.25	30.23	NO	
Coat Room	support	136	5.44					0.00	5.44	NO	
Room 21	classroom	961	38.44				3	5.25	33.19	NO	
Room 22 - Assistive Technology	classroom	457	18.28					0.00	18.28	NO	
Storage	storage	67	2.68					0.00	2.68	NO	
Room 23 - Conference	conference	339	13.56				2	3.50	10.06	NO	
Library	media	2021	80.84				6	10.50	70.34	NO	
Library Office	office	190	7.6					0.00	7.60	NO	

Window Type	Width	Hieght	Projection	Venting
1 - Double Hung	38.5	7.25	-	1.94
2 - Double Hung	31.5	8	-	1.75

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)