

# **Worcester Public Schools**

## **Ventilation Assessment & COVID-19 Mitigation Strategies**

for

### **Burncoat Middle School Worcester, MA**



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**Prepared by:**

**Nault Architects Inc  
71 Hope Ave  
Worcester, MA 10603**

**Seaman Engineering Corporation  
22 West St, Unit C  
Milbury, MA 01527**

**&**

**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 or 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:

### Burncoat Middle School:

Burncoat Middle School is located in the Burncoat Quadrant of Worcester at 135 Burncoat Street. The School was built in 1952, houses grades 7-8, has 45 classrooms and the building is 147,296 square feet. The original windows have been replaced.

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## **1) Mechanical Ventilation Report**

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## **I. EXECUTIVE SUMMARY**

This report briefly describes the existing ventilation systems at the existing Burncoat Middle 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<sub>2</sub> (carbon dioxide in ppm), CH<sub>2</sub>O (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 Burncoat Middle 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.

Most of the HVAC systems supporting the Burncoat Middle School are 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.

Many of the classroom HVAC systems supporting the school are near or above the 3 ACH requirement. In addition, most of the building areas are supported by classroom unit ventilators which have the ability to introduce additional outdoor air for higher O.A. ventilation and air exchange rates subject to outdoor ambient conditions and equipment limitations. The AHU’s serving the gymnasium and auditorium also have the ability to provide additional outside air.

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

Except for potentially the auditorium air handling system, most of the existing HVAC systems will not support increased filtration above MERV 8 either due to physical equipment limitations (i.e., fan coils limited to 1” filters) or due to fan capacity limitations. Increased filter 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 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 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 Burncoat Middle 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 Burncoat Middle 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 Burncoat Middle School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
<b>General Classrooms</b>	Unit Ventilators	CCM - #1 & #2 ECCM - #1 or #3 (*see note below)
<b>Library</b>	HV Air Handler	CCM - #1 & #2 ECCM - #1 or #3 (*see note below)
<b>Gymnasium</b>	HV Air Handler	CCM - #1 & #2 ECCM - #3
<b>Auditorium</b>	HV Air Handler	CCM - #1 & #2 ECCM - #3
<b>Cafeteria</b>	Unit Ventilators	CCM - #1 & #2 ECCM - #3
<b>Office &amp; Nurse</b>	Packaged Rooftop Units	CCM - #1 & #2 ECCM - #1 or #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.*

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<sub>2</sub> (carbon dioxide in ppm)
- CH<sub>2</sub>O (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<sub>2</sub> levels were low since space CO<sub>2</sub> 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:

<u>Distribution Configuration</u>	<u>ZDE</u>
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 heated with 2-pipe classroom unit ventilators. These units are fed with hot water from a central boiler plant. Most of the units 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 classroom unit ventilators are located along exterior walls with each having an outdoor air louver and associate control dampers to allow outdoor air to enter the classroom space through the unit ventilator. During occupied periods, the unit fans run continuous to provide space ventilation and electric operators modulate the hot water 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 water valve opening when there is a need for heating or economizer (OA) cooling.

Although classrooms vary in size and airflow, for an average classroom size of 750 SF, the system delivers approx. 400 CFM of outdoor air to the classroom spaces via the unit ventilator. Where unit ventilators are present, exhaust is generally supported by roof exhaust fans connecting to the supporting rooms via above ceiling ductwork and vertical duct chases. The exhaust fans appear to exhaust a percentage of the minimum amount of outside air for ventilation and are not sized to exhaust 100% outside air which occurs when the unit ventilators go into free cooling/economizer mode.

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 zone air distribution effectiveness of 1.0, as most classrooms with the current unit ventilator system are, a room size of 750 SF with 26 occupants (25 students + 1 teacher) would require 350 CFM of outdoor air. Hence the current systems operating at approx. 400 CFM+/- provides more than the current code required outdoor air to the rooms.

The cafeteria is also supported by classroom style unit ventilators. According to old HVAC plans these units are capable of providing up to 100% outdoor air which provides sufficient ventilation for this space as well as pandemic level ventilation in excess of the optimal 5 ACH.

Science & Art Rooms:

The science and art rooms are supported by the same types of unit ventilators and exhausts as the normal classroom systems. The rooms are supplied with the typical classroom 400 CFM of outside air and associated exhaust air.

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. It appears the buildings ventilation levels for these rooms maybe non-compliant, especially if they are used as actual labs with chemical use and art rooms. If the rooms are not used as labs or art rooms the lower typical classroom ventilation levels may apply.

Bathroom and local exhaust requirements are supported by roof mounted centrifugal exhaust fans. These exhaust systems appear to meet or exceed the current ventilation codes for the spaces serviced.

Auditorium and Gym:

Outdoor air for the gymnasium and auditorium is supported by air handling units. The air handlers are fitted with a mixing box, filter section, hot water coil and supply fan. The filters on the air handler are 2" thick pleated filters with an estimated MERV rating of 8. The unit has 2" thick pleated filters with an estimated MERV rating of 8.

This unit may be able to support improved filtration pending unit airflow testing to evaluate the unit's capabilities. However, as this unit conveys 100% outside air, it is not filtering contaminated space air but only outside air and as such the space air quality would not benefit greatly by increasing filtration at the risk of a potential reduction in air volume from higher pressure drop faster loading higher MERV filters.

HVAC systems within the space are controlled by building EMS system to a varying degree.

Current code would require the following outdoor air for the respective spaces:

- Gymnasium: 0.3 CFM per SF play area (+ undetermined spectator area)
- Auditorium: 5 CFM per person of outside air plus 0.12 CFM per SF

The air handling units are fairly old and as such we suspect they cannot support much better than a MERV 8 filter however testing and confirmation of fan capabilities could be done to verify such ability. If increased to MERV 13, more frequent replacement of the filters shall be required to avoid reduction in airflow as filters load.

Offices:

The main office and nurse's office are supported by two (2) packaged roof-top units. These units incorporate filter racks with MERV 8 filters, DX cooling and supply fan. The units have intake air hoods however exhaust/relief may be limited.

The units are old and limited in fan capacity and as such we suspect will be limited to MERV 8. However, testing could be done to verify if improved filtration could be supported. If filtration is increased to MERV 13, more frequent replacement of the filters shall be required to avoid reduction in airflow as filters load.

Controls:

Most of the major HVAC systems supporting the school are controlled by a building energy management system (EMS) to some degree. The EMS system is currently supported by Automated Building Systems, Inc (ABS). Although a further review with the EMS vendor would be required to ascertain the extent of this system it is our current understanding that the system controls all the air handlers and unit ventilators.

The control drawings for the auditorium and gymnasium reflect the utilization of CO<sub>2</sub> sensors which we expect are used for outdoor air demand ventilation reset however the sequence of operation was not indicated. The CO<sub>2</sub> reset should be disabled during this pandemic condition so as not to reduce the amount of outdoor air. In addition, the gymnasium system appears to reference occupancy sensor control which should be disabled to maintain ventilation levels at normal occupied levels for improved purge during occupied periods.

Control drawings for the classroom unit ventilators (UV) reflect fan and coil control with damper control unknown. Increased OA (see CCM #2) may require upgrade of the UV controls to achieve.

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:

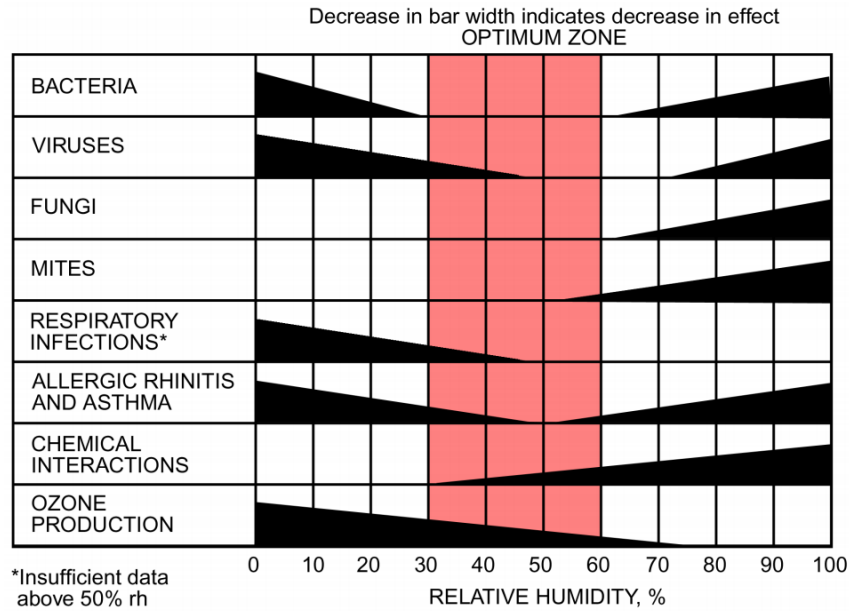
During our inspection we obtained spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO<sub>2</sub> (carbon dioxide in ppm)
- CH<sub>2</sub>O (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<sub>2</sub> levels were low since space CO<sub>2</sub> 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 Burncoat Middle 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 Burncoat Middle 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 Burncoat Middle School have a design outdoor air exchange rate of approx. 3 or greater meeting the bare minimum criteria. 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 than what this document considers the bare minimum outdoor air exchange rate may meet or exceed the most current ventilation standards dependent on the space 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.

Burncoat Middle 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
<b>1st Floor G Wing</b>											
Girls Locker Rm	65.6	63	432	0.98	0.14	1847	10.416	19238	400	1.2	
<b>1st Floor L Wing</b>											
L.D. Rm L-7GB	70.2	53.8	492	0.85	0.11	187	8.33	1558	N/A	N/A	
Classroom Rm L6	71.8	53.5	431	0.57	0.08	465	9	4185	400	5.7	
Classroom Rm L9	72.6	53	445	0.32	0.09	703	9	6327	400	3.8	
Science Classroom Rm L12	79	51.1	473	1.08	0.12	831	8.583	7132	400	3.4	
<b>1st Floor C Wing</b>											
Corridor	79.5	46.8	448	1.19	0.12	755	8.166	6165	N/A	N/A	
Classroom Rm C10	72.6	50.8	435	1.01	0.22	703	9	6327	400	3.8	
Main Office	69.4	57.8	535	1.58	0.33	470	9.083	4269	750	10.5	
Classroom 203	73.7	27.5	461	0.72	0.1	941	10	9410	400	2.6	
<b>1st Floor A Wing</b>											
Theater/Classroom	71	51.2	458	1.01	0.12	2402	10.166	24419	800	2	
<b>2nd Floor G Wing</b>											
Gymnasium	68	57.7	422	0.52	0.13	6713	23.083	154956	N/A	N/A	
<b>1st Floor H Wing</b>											
Dance Studio RM H-15, H-16	73.4	53.5	446	1.01	0.08	1777	15.166	26950	N/A	N/A	
Mid. School Music Rm H-14	73.4	52.5	446	1.01	0.08	1043	15.166	15818	N/A	N/A	
Rehearsal Classroom Rm H-8	74.2	53.3	446	1.01	0.12	1627	13.083	21286	N/A	N/A	
<b>1st Floor S-Wing</b>											
Teen Care Center RM S12	75.2	48.9	442	0.89	0.11	1140	9	10260	400	2.3	
Classroom Rm S14	73.7	49	434	1.1	0.08	791	9	7119	400	3.4	
Lobby	74.1	47.9	480	1.01	0.08	176	9	1584	N/A	N/A	
Health Suite	74.9	46.9	550	1.01	0.08	255	9	2295	N/A	N/A	
<b>2nd Floor L-Wing</b>											
Classroom Rm L25	68.1	59.1	480	1.01	0.12	710	9	6390	400	3.8	
Classroom Rm L28	71.1	53.1	435	1.01	0.12	730	9	6570	400	3.7	
Teachers Lounge Rm L30	73.2	50.9	451	1.01	0.12	965	9	8685	400	2.8	
<b>2nd Floor C-Wing</b>											
Classroom Rm C22	74.5	48.5	439	1.12	0.16	711	9	6399	400	3.8	
Conference Rm C23	74.1	50.2	437	1.01	0.018	457	9	4113	400	5.8	
Library	74.6	46.6	482	1.1	0.12	2226	9.083	20219	1200	3.6	
<b>2nd Floor A-Wing</b>											
Auditorium	72	51.2	445	1.12	0.17	7685	25.5	195968	N/A	N/A	
Cafeteria	70.8	52.7	465	1.01	0.1	4660	10.583	49317	6240	7.6	
Kitchen	71.7	52.9	465	1.01	0.08	1613	11	17743	400	1.4	
Music Rm A11	72.2	52.9	465	1.01	0.08	1209	9	10881	800	4.4	
Art Room Rm A12	72.8	50.9	43.7	1.02	0.12	1127	9	10143	400	2.4	

*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.*



**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.

Burncoat Middle 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. Velocity (FPM)	Proposed CCM #	Proposed ECCM #	Notes
G-1	Gym (G-Wing)	5000	5000	100	N/A	8	N/A	#1, #2	#3	b
G-2	Gym (G-Wing)	5000	5000	100	N/A	8	N/A	#1, #2	#3	b
RTU-1	Health Suite (S-Wing)	N/A	N/A	N/A	(2) 20x25x2 (2) 20x20x2	8	N/A	#1, #2	#3	
RTU-2	Health Suite (S-Wing)	N/A	N/A	N/A	(2) 20x25x2 (2) 20x20x2	8	N/A	#1, #2	#3	
HV-AUD-1	Auditorium (A-Wing)	10000	10000	100	(2) 16x25x2 (2) 20x25x2 (4) 16x20x2	8	469	#1, #2	#3	b
HV-AUD-2	Auditorium (A-Wing)	10000	10000	100	(2) 16x25x2 (2) 20x25x2 (4) 16x20x2	8	469	#1, #2	#3	b
CUV's	Classrooms	varies	varies	varies	varies	8	varies	#1, #2	#1, #3	a

**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. Disable any CO2 demand ventilation reset or occupancy sensor-based system shutdown (during scheduled occupied periods) 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 Burncoat Middle 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 Burncoat Middle 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., CO2 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 have the ability to increase outdoor air for higher outdoor air ventilation and air exchange rate. However, those systems with pneumatic controls may require a control upgrade to accomplish such.

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.

Higher filtration on most of the AHU's may be considered subject to unit fan capabilities. Most, other HVAC systems including the classroom unit ventilators 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 Burncoat Middle Schools case they could be installed in the supply air duct of the respective mixed air handling systems as well as classroom unit ventilators. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Burncoat Middle 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 on 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 3<sup>rd</sup> 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**







S - Wing																		
First Floor																		
N0	classroom	491	19.64													0.00	19.64	NO
S10	classroom	491	19.64													27.08	-7.44	YES
Health Suite / Kitchenette	support	201	8													13.54	-5.54	YES
Health Suite - Utility	support	57	2.28													0.00	2.28	NO
Health Suite - 120	toilet	46	1.84													0.00	1.84	NO
Health Suite - Office 5	office	134	5.36													13.54	-8.18	YES
Health Suite - Resting	support	78	3.12													9.03	-5.91	YES
Health Suite - Office 4	office	74	2.96													13.54	-10.58	YES
Health Suite - Office 3	office	74	2.96													13.54	-10.58	YES
Health Suite - Office	office	71	2.84													13.54	-10.70	YES
Health Suite - Reception	support	71	2.84													0.00	2.84	NO
Health Suite - Entrance	entry	37	1.48													0.00	1.48	NO
Health Suite - Lobby	entry	175	7													0.00	7.00	NO
Health Suite - Exam 1	support	86	3.44													0.00	3.44	NO
Health Suite - Exam 2	support	88	3.52													0.00	3.52	NO
Health Suite - Resting	support	121	4.84													0.00	4.84	NO
Custodian - Support	support	71	2.84													0.00	2.84	NO
Custodian - Toilet	toilet	50	2													0.00	2.00	NO
Storage Room (off Great Rm)	storage	218	8.72													0.00	8.72	NO
Custodian Storage	storage	96	3.84													0.00	3.84	NO
S12 - Teen Care Center	classroom	1190	45.56													58.68	-13.12	YES
S12 - Wash Room	toilet	59	2.36													0.00	2.36	NO
S12 - Wash Room	toilet	27	1.08													0.00	1.08	NO
S12 - Storage	storage	30	1.2													9.03	-7.83	YES
S12 - Office	office	71	2.84													0.00	2.84	NO
S12 - Waiting Room	support	60	2.4													0.00	2.40	NO
S12 - Office (shared)	office	111	4.44													13.54	-9.10	YES
S13	classroom	519	20.76													27.08	-6.32	YES
S14	classroom	790	31.6													40.63	-9.03	YES
Boys' Room / Storage	storage	29	1.16													0.00	1.16	NO
Boys' Room / Storage	toilet	267	10.68													9.03	1.65	NO
Custodian - Support	support	34	1.36													0.00	1.36	NO
Teacher's Toilet	toilet	47	1.88													0.00	1.88	NO
Girls' Room / Storage	toilet	259	10.36													9.03	1.33	NO

Window Type	Width	Height	Projection	Venting
1 - Hopper	35	15	11	3.82
2 - Hopper	42	16	9	3.63
3 - Hopper	36	32	26	12.28
4 - Hopper	35	20	18	6.88
5 - Hopper	34	20	9	3.38
6 - Hopper	35	26	20	8.47
7 - Hopper	33	15	12	4.00
8 - Hopper	35	15	13	4.51
9 - Hopper	36	31	8	3.72
10 - Hopper	36	19	9	3.44
11 - Hopper	44	21	18	8.13
12 - Hopper	45	16	11	4.66

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