Region 10 Schools Commissioning and Ventilation Systems Assessment

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Executive Summary

CES Inc, was retained to conduct a Facility Assessment of Region 10 Public Schools to determine existing conditions of ventilation equipment serving all spaces.

Each school listed below was assessed by using existing plans and diagrams of the schools as well as documentation available for the existing ventilation systems. This Report, in addition to published re-opening guidance from American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) may be used to decide short, medium and long term upgrades. Each School has a unique age, ventilation and exhaust system configuration, layout, and construction type.

- **Region 10 High School,** 24 Lyon Road, Burlington
- **Region 10 Middle School,** 24 Lyon Road, Burlington

The recommendations included are based on the best available knowledge at the time of writing and include information from ASHRAE released July 17, 2020 and updated April 27, 2021. Referenced information is attached for review as needed.

The High School and Middle School area a combined building with a total area of approximately 315,000 square feet. Classrooms in both the High School and Middle School are primarily served by unit ventilators and have adequate ventilation air. However, existing unit ventilators do no provide cooling and may become an increased maintenance item due to age and decentralized nature of equipment. If building was to be renovated dedicated outside air units are recommended to provide ventilation air for all classrooms areas along with VRF heating / cooling system. **A further analysis is required to determine if existing building electrical systems could handle increased loads or would need to be upgraded.**

Existing roof top units, RTU-30, RTU-36, and RTU-9 were found to be deficient with respect to existing ventilation code minimum outside air requirements. Further to this RTU-21, 22, 23, 24, 25, 26, 30, 31, 32, 33, 36 and 41 were existing units re-used during 2005 renovation project. These units are in poor condition and nearing their end of useful life, a plan to replace these units should be put in place.

Further consideration should be given to supplementary technologies to help improve indoor air quality in spaces that have limited or no access to outside air ventilation in the short to medium term. Refer to filtration, bi-polar ionization and ultraviolet germicidal irradiation technology summary included in the Industry Consensus section of report. Portable air purifier systems that contain a combination of these technologies should be considered for deficient areas as a short term remediation.

It should be noted that the following summary and recommendations are not fully engineered solutions and as such are not ready to be implemented without further analysis in some cases. Follow up is required to provide construction documents and analysis of specific systems and areas as noted.

Overview

General

The scope of this assessment is with respect to the existing ventilation systems, including recommendations and options to improve the performance of the ventilation systems, and to addresses potential methods of air treatment with respect to COVID-19 and viruses similar to COVID-19 (henceforth referred to as COVID-19).

The intent of this assessment with respect to recommendations and options is to provide basic descriptions, advantages, and disadvantages, as the case may be, of each of the recommendations and options for the varying types of ventilation systems serving the Vernon Public schools.

The scope of this assessment is generally with respect to system type; unless otherwise indicated (such as ventilation calculations on an air handling unit by air handling unit basis), each air handling unit is not individually addressed. For example, if there are five packaged rooftop units configured the same and serving similar occupancies, the assessment will generally address those rooftop units as a system type, not individually.

Industry Consensus

As, to the best of CES's knowledge as of the date of this assessment, there is no general consensus within the architectural/engineering, hygiene, science, and similar communities with respect to correlations between air movement within spaces and virus transmission for schools and similar facilities, this assessment does not evaluate the air movement within spaces, nor does it include recommendations to modify the air movement within spaces. That is not to say that air movement within spaces does not affect virus transmission; it is to say only that the science is too incomplete to confidently determine the effect of air movement on virus transmission.

As, to the best of CES's knowledge as of the date of this assessment, there is general consensus within the architectural/engineering, hygiene, science, and similar communities with respect to correlations between outside air ventilation within spaces/buildings and virus transmission for schools and similar facilities, this assessment assumes that in general the greater the outside air ventilation rates the lower the virus transmission rates[1].

[1]Based on standard dilution calculation methodology. The greater the outside air ventilation rates, the quicker the removal times of airborne contaminants from dilution of the space air with outside air.

However, the ASHRAE Position Document on Infectious Aerosols (April 14, 2020, expires April 14, 2023) does not take a position with respect to how much outside air ventilation rates should be increased above the rates included in ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality. The ASHRAE position document indicates, with respect to increasing outside air ventilation rates (dilution), "…it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions (infectious doses vary widely among different pathogens) and whether these reductions warrant the associated costs…".

As, to the best of CES's knowledge as of the date of this assessment, there is general consensus within the architectural/engineering, hygiene, science, and similar communities with respect to correlations between relative humidity and virus transmission for schools and similar facilities, this assessment assumes that relative humidities in the 40% to 60% range are optimum[2] with respect to minimizing virus transmission rates.

[2]From a 1986 paper titled 'Indirect Health Effects of Relative Humidity in Indoor Environment' (Arundel, Sterling, Biggin, & Sterling), which includes a chart sometimes referred to as the 'Sterling Chart'.

As, to the best of CES's knowledge as of the date of this assessment, there is general consensus within the architectural/engineering, hygiene, science, and similar communities that the various technologies available to reduce virus transmission, including particulate filtration, ultraviolet germicidal irradiation (UVGI), and bi-polar ionization, as well as increasing outside air ventilation rates, are complementary technologies, in that they employ different methods of reducing virus transmission. That is, the more technologies implemented the greater the probability of the reduction of virus transmission.

With respect to bi-polar ionization, CES' experience is that much of the literature supporting it and explaining the science behind it is produced by either manufacturers of bi-polar ionization equipment, or by companies or individuals paid by the manufacturers of bi-polar ionization equipment to validate their claims with respect to product effectiveness. The literature produced by such organizations appears to CES to have scientific merit, however such determination of scientific merit is beyond the expertise of CES, therefore any recommendations herein with respect to bi-polar ionization are based on assumption that the manufacturer's claims are scientifically valid. As of the date of this assessment, The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has not taken a position on the effectiveness of bi-polar ionization technologies.

Information Available

Mechanical (HVAC) system drawings from 2005 renovations and additions project were made available to CES; the information in this assessment with respect to the operation of the systems, the outside air ventilation rates, and similar, is based on the information gathered in the field during CES' site visits, the information on the drawings, and on CES' experience with the operation of mechanical systems similar to the systems serving the school.

Determination of Outside Air Ventilation Rates

The International Mechanical Code (IMC)/ASHRAE 62.1 is used for calculating the outside air ventilation rate requirements for all of the spaces in schools. For most of the spaces in a school, the IMC/ASHRAE 62.1 outside air ventilation rate calculation methodology includes both an area component (cfm/sq.ft.) and an occupant component (cfm/person), added together to determine the required outside air ventilation rate for each space. The IMC/ASHRAE 62.1 also includes prescribed occupant densities (people/1,000 sq.ft.) for calculating the occupant component, and those prescribed densities are used for the outside air ventilation rate calculations included in the Analysis section of this assessment.

However, the IMC/ASHRAE 62.1 prescribed occupant densities may not be applicable for some, if not many, of the spaces in this school, as the school district may, for the purposes of reducing the probability of the transmitting viruses, use student/occupant densities that are less than the prescribed occupant densities in the IMC/ASHRAE 62.1. For such spaces the required outside air ventilation rate would be less than the required outside air ventilation rate calculated using the prescribed occupant densities in the IMC/ASHRAE 62.1.

This assessment does not address the actual occupant densities, as the factors used for determining the actual occupant densities are generally unrelated to the HVAC systems, and therefore are beyond the scope of this assessment. However, this assessment includes tables (see Appendix A) that allow the school district to determine the required outside air ventilation rates for spaces where the occupant densities are less than the IMC/ASHRAE 62.1 prescribed occupant densities.

Options for Determining the Outside Air (OA) Ventilation Rates

There are three primary options for determining the outside air ventilation rates for the various spaces throughout the school, where each option has its own considerations, many of which are included in this assessment. However each School District may also have priorities and policies that affect the decisions, therefore the three options.

Option 1 - OA Ventilation Rates Based on Code Prescribed Occupant Densities

One consideration with respect to adjusting/balancing equipment to provide outside air ventilation is that, because the occupant densities during virus transmission reduction conditions may be less than those during normal conditions, where equipment is balanced for the lower outside air ventilation rates of the virus transmission reduction conditions, such equipment will then need to be adjusted again for the higher outside air ventilation rates when the occupant densities revert back to the normal conditions.

As this many be considered impractical, and as adjusting the equipment for the higher outside air ventilation rates for the normal conditions would in effect provide additional outside air ventilation for the lower occupant densities of the virus transmission reduction conditions, the school district should consider balancing only for the higher outside air ventilation rates of the normal conditions.

The calculations for those higher outside air ventilation rates (using the IMC/ASHRAE 62.1 prescribed occupant densities) are included in the Analysis section of this assessment.

Option 2 - OA Ventilation Rates Based on Actual Occupant Densities

If the School District plans to maintain the occupant densities of the virus transmission reduction conditions for the foreseeable future, adjusting the outside air ventilation rates to the lower values, using the tables in Appendix A, is an option.

Option 3 - OA Ventilation Rates Greater Than Option 1

As noted in the Industry Consensus section of this assessment, the general consensus within the architectural/engineering, hygiene, science, and similar communities is that the greater the outside air ventilation rates the lower the virus transmission rates. See the following section - Increasing Outside Air Ventilation Rates - for considerations and additional information if this option is selected.

Increasing Outside Air Ventilation Rates

In general, mechanical equipment and systems are sized and selected to meet the heating and cooling loads on design winter days and design summer days respectively. Since there are typically less than a dozen such design winter days and design summer days every year, mechanical equipment and systems almost invariably have excess heating and cooling capacity on all the other days of the year, and that excess capacity can be used to temper (to room temperature) additional outside air ventilation.

This generally leads to three options for increasing the outside air ventilation rates:

Option 1: Provide controls that allow for increasing the outside air ventilation rates, except that when the spaces served are not being maintained at the space heating and cooling temperature setpoints, as might be the case on design winter days and design summer days respectively, the outside air ventilation rates are reduced.

In addition to using space temperature setpoints for limiting the outside air ventilation rates, relative humidity ideally would also be used as a limiting criteria, because in general increasing outside air ventilation rates in the winter leads to reduced relative humidity and increasing outside air ventilation rates in the summer leads to increased relative humidity (see the Industry Consensus paragraph above regarding relative humidity).

Digital control systems typically have the capability to provide such control, however implementing such control will in many cases involve adding sensors, replacing actuators, reprogramming, and similar costs.

Option 2: Balance the equipment and systems for outside air ventilation rates higher than design.

In this case the space heating and cooling temperature setpoints will still likely be maintained during much of the year, and possibly during all of the year with the exception of design and near design winter days and design and near design summer days, with the understanding and the expectation that on the design and near design winter days the spaces may be maintained at temperatures several degrees below the space heating temperature setpoints and that on the design and near design summer days the spaces may be maintained at temperatures several degrees above the space cooling temperature setpoints.

Similarly there should be both an understanding and an expectation that with increased ventilation rates the relative humidities in the spaces will likely be lower than they would otherwise be through much of the winter and higher than they would otherwise be through much of the summer (see the Industry Consensus paragraph above regarding relative humidity).

This option is likely the primary option for non-digital control systems (short of replacing such control systems with new control systems).

Option 3: The same as Option 2, but provide manual controls that allow the maintenance staff to manually reduce the outside air ventilation if/when the space temperatures and/or relative humidities were unacceptable.

The maintenance staff would also have to readjust for the additional outside air ventilation when the outside air conditions appeared favorable enough that increasing the outside air ventilation rates would likely not lead to unacceptable space temperatures and/or relative humidities.

This option is included primarily for comprehensiveness, as manually adjusting the outside air ventilation would place a significant burden on the maintenance staff, not only with respect to labor hours but also with respect to training; such adjustment should only be done by maintenance staff that is trained and informed as to the implications and potential outcomes of manually adjusting ventilation rates. That is, from CES' experience for most school districts this option would be considered too onerous and impractical to implement, and for that reason this option is recommended only if the school district if fully aware of the implications of implementing manual control.

As tempering outside air to room temperature for schools and similar facilities is a significant operational cost with respect to energy consumption, higher utility bills (both fuel and power as applicable) should be expected if the outside air ventilation rates are increased (unless new energy recovery systems are implemented along with increasing the outside air ventilation rates). Additionally, increasing outside air ventilation rates should be done with caution in the Northeast, as increasing outside air ventilation rates increases the possibility exposing heating coils to freezing temperatures in the winter, thereby increasing the possibility of coils freezing.

Natural Ventilation

The International Mechanical Code allows for either natural ventilation or mechanical ventilation for spaces within buildings. In order for a space to meet the code requirements for natural ventilation, the aggregate operable window and door areas of that space must be equal to or greater than 4% of the floor area.

The following, regarding natural ventilation, is from the ASHRAE Position Document On Infectious Aerosols (14 Apr 20, Expires 14 Apr 23):

"Many buildings are fully or partially naturally ventilated. They may use operable windows and rely on intentional and unintentional openings in the building envelope. These strategies create different risks and benefits. Obviously, the airflow in these buildings is variable and unpredictable, as are the resulting air distribution patterns, so the ability to actively manage risk in such buildings is much reduced. However, naturally ventilated buildings can go beyond random opening of windows and be engineered intentionally to

> achieve ventilation strategies and thereby reduce risk from infectious aerosols. Generally speaking, designs that achiever higher ventilaton rates will reduce risk. However, such buildings will be more affected by local outdoor air quality, including the level of allergens and pollutants within the outdoor air, varying temperature and humidity conditions, and flying insects."

For the reasons noted in the ASHRAE position paper, and because there are other considerations, such as security, that are beyond the purview of this assessment, the operable window and door area calculations necessary to determine whether or not specific spaces in the school qualify as naturally ventilated spaces are not included in this assessment.

Therefore this assessment does not address natural ventilation. However that is not to suggest that the School District should or should not consider natural ventilation for some spaces. The measurements and calculations required to verify whether or not spaces qualify as code compliant naturally ventilated spaces, as noted above, are simple calculations, relatively easily performed by School district personnel.

Pressurization

Pressurization generally refers to maintaining the various spaces throughout buildings at different air pressures, as air naturally migrates from higher air pressure spaces to lower air pressure spaces. In general, spaces at higher air pressures are less likely to be contaminated by infectious aerosols migrating from other (lower pressure) spaces, and vice versa - spaces at lower air pressures are more likely to be contaminated by infectious aerosols migrating from other (higher pressure) spaces.

Pressurization is accomplished by the HVAC systems, where in general, the greater the difference between the air supplied to a space and the air removed from a space the higher the air pressure of the space, and vice versa - the lower the difference between the air supplied to a space and the air removed from a space the lower the air pressure of the space.

Pressurization of spaces can be a very effective strategy for minimizing virus transmission, and therefore there are specific requirements for almost all health care occupancies with respect to pressurization, to contain infectious aerosols from spreading from the spaces most likely to have infectious aerosols to other spaces.

However, the spaces most likely to have infectious aerosols in buildings such as schools are, for all practical purposes, unpredictable. Therefore attempting to design HVAC systems that provide for pressurization of the various spaces within a school, to minimize the migration of infectious aerosols between spaces, would likely be futile, and such pressurization systems could even conceivably increase the risk of virus transmission. Therefore pressurization of the various spaces within building are not included in this assessment.

Though pressurization is not addressed in this assessment, the school district may want to consider creating an isolation room in each school. Isolation rooms in health care occupancies are exhausted to maintain them at a negative pressure with respect to all of the adjacent spaces, thereby reducing the probability that the occupants of the isolation room could transmit a virus to others. Therefore, if an isolation room is designated, exhaust ventilation for that room is recommended. Isolation rooms are currently not required by code for schools, but may be in future versions of code.

Region 10 High School Ventilation Systems Assessment

Existing Conditions

Classroom Ventilation Systems

General Description & Operation

Classroom ventilation is primarily provided by unit ventilators throughout the school's first and second floor area H and J. Existing unit ventilators are top supply bottom face return and have a supply air fan, heating coil, and outside air/return damper. Temperature controls in classrooms is by digital thermostat.

Classrooms in Area F are ventilated by mixed air roof top unit, **RTU-21**. 1st floor G CADD classrooms are served by **RTU-32**. Both roof top units provide heating, cooling, and ventilation air. Units have a supply air fan, return/exhaust fan, heating coil, DX cooling coil, MERV-10 filters, and outside air damper.

Science classrooms in Area H and J are ventilated by 100% outside air roof top units **RTU-28, 29, and 34**. Roof top units serving science classrooms are heating and ventilation only and have a supply air fan, return/exhaust fan, heating coil, heat wheel, MERV-10 filters, and outside air damper.

Gymnasium Ventilation Systems

General Description & Operation

High School Gymnasium is served by (2) single zone mixed air heating and ventilation only roof top units, **RTU-12** and **RTU-20**. Units include supply fan, return fan, hot water heating coil, and MERV-10 filters.

Exhaust air is provided by (2) roof mounted exhaust fans.

Gym Heating and Ventilation Unit RTU-12

Music Rooms Ventilation Systems

General Description & Operation

High School Music classrooms in Area E are ventilated by existing mixed air variable air volume roof top unit, **RTU-17**.

Fitness and Weight Rooms Ventilation Systems

General Description & Operation

Fitness and Weight Room is served by **RTU-15** and **RTU-16** located on roof. Units provides outside air along with heating and cooling supply air. System has a ducted supply and return with ceiling supply diffusers. Unit has MERV-10 filters.

Cafeteria and Kitchen Ventilation Systems

General Description & Operation

High School Cafeteria is served by **RTU-7** located on roof above. Unit provides outside air along with heating and cooling supply air. MERV-10 filters.

High School Cafeteria RTU-7

Auditorium and Stage Ventilation System

General Description & Operation

High School Auditorium is served by **RTU-15** located on low roof. Unit provides outside air along with heating and cooling supply air. System has a ducted supply and return with ceiling supply diffusers. Unit has MERV-10 filters.

Media Center Ventilation System

General Description & Operation

High School Media Center in Area H is ventilated by existing mixed air variable air volume roof top unit, **RTU-30**.

Media Center is served by **RTU-30** located on roof. Units provide outside air along with heating and cooling supply air. Systems have a ducted supply and return with ceiling supply diffusers and return registers. Units have MERV-10 filters.

Administration and Main Office Ventilation System

General Description & Operation

Administration offices in Area F, and G are heated, cooled, and ventilated by mixed air roof top units, **RTU-23, 24, 25, 26, and 27**.

Administration Office Area RTU-26

1st floor Area J office and conference rooms are served by RTU-31 and 33.

Unit provide outside air along with heating and cooling supply air. System has a ducted supply and return with ceiling supply diffusers and return registers. Unit has MERV-10 filters.

Nurse's Office Ventilation System

General Description & Operation

Nurse's office and adjacent rooms in Area F are heated, cooled, and ventilated by a mixed air roof top unit, RTU- 22. Unit provides outside air along with heating and cooling supply air. System has a ducted supply and return with ceiling supply diffusers and return grilles. Unit has MERV-10 filters.

Control System

All systems are controlled by direct digital controls through Trane Tracer Building Management System. Thermostats are by Trane, flat front non-adjustable type thermostats in classrooms and adjustable thermostats with digital display in office areas.

Typical Classroom Thermostat

Typical Office Thermostat

Analysis

Classroom Ventilation Systems

Functionality & Current Operation

Classrooms ventilation is primarily provided by unit ventilators, **UV-1 and UV-2**, throughout area H and J first and second floors. Unit ventilators are in fair to good shape. Units are designed to function as both heating and ventilation source. Units are capable of providing adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 450 CFM.

Typical classroom is approximately 680 square feet.

680	sq.ft.	x	35	people/1,000 sq.ft.	=	24	people
680	sq.ft.	x	0.12	cfm/sq.ft.	=	82	cfm
24	people	x	10	cfm/person	=	240	cfm
Total	(rounded up to nearest 5)					325	cfm

Classrooms in Area F are ventilated by mixed air roof top unit 21. Unit is in fair condition. There is (1) large computer lab, (1) small computer lab and (1) laboratory classrooms served by **RTU-21**. Units is capable of providing adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 1200 CFM.

1st floor G CADD classrooms and J area bathrooms are served by **RTU-32**. Unit is in fair condition. (2) CADD classrooms served by RTU-32. Units is capable of providing adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 1500 CFM.

1,107	sq.ft.	x	35	people/1,000 sq.ft.	=	39	people
1,107	sq.ft.	x	0.12	cfm/sq.ft.	=	133	cfm
39	people	x	10	cfm/person	=	390	cfm
Total	(rounded up to nearest 5)					525	cfm

Typical science classroom is approximately 1,353 square feet. Science classrooms in 2nd floor Area H and J are ventilated by 100% outside air roof top units, **RTU-28, 29, 34.** Units are in fair condition.

1,353	sq.ft.	x	25	people/1,000 sq.ft.	=	34	people
1,353	sq.ft.	x	0.18	cfm/sq.ft.	=	244	cfm
34	people	x	10	cfm/person	=	340	cfm
Total	(rounded up to nearest 5)					585	cfm

RTU-28, RTU-29 and RTU-34 are noted as 100% outside air with 4,950, 4575, and 6,000 CFM respectively, units are capable of providing adequate outside air based on site survey and schedules reviewed.

(2) Art Classrooms and Audio/Video Studio is served by **RTU-24.** Typical art classroom is approximately 1,558 square feet. Units is capable of providing adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 3,150 CFM.

1,558	sq.ft.	x	20	people/1,000 sq.ft.	=	32	people
1,558	sq.ft.	x	0.18	cfm/sq.ft.	=	281	cfm
32	people	x	10	cfm/person	=	320	cfm
Total	(rounded up to nearest 5)					605	cfm

Gymnasium Ventilation Systems

Functionality & Current Operation

High School Gymnasium is served by a single zone mixed air heating and ventilation only roof top unit, **RTU-12**. This unit provides 2,000 CFM outside air per schedule reviewed.

Main Gymnasium - Non-Spectator Area

5,337	sq.ft.	x	0.30	cfm/sq.ft.	=	1,605	cfm

Auxiliary Gymnasium - Non-Spectator Area

1,397	sq.ft.	x	0.30	cfm/sq.ft.	=	420	cfm

Main and Auxiliary Gymnasium - Spectator Area

3,871	sq.ft.	x	150	people/1,000 sq.ft.	=	580	people
3,871	sq.ft.	x	0.06	cfm/sq.ft.	=	232	cfm
580	people	x	7.5	cfm/person	=	4,350	cfm
Total	(rounded up to nearest 5)					4,585	cfm

High School Auxiliary Gymnasium is served by a single zone mixed air heating and ventilation only roof top unit, **RTU-20**. This unit provides 2,000 CFM outside air per schedule reviewed.

Exhaust air is provided by (2) roof mounted exhaust fans, **EF-24** and **EF-25**, each exhaust fan provides 2,000 CFM of exhaust for a total of 4,000 CFM exhaust air.

Total outside air provided by **RTU-12** and **RTU-20** appears to be undersized for current ventilation code. Current code required outside air is 6,610 CFM with existing units providing 4,000 CFM of outside air to the space.

Fitness and Weight Rooms Ventilation Systems

Functionality & Current Operation

Fitness and Weight Room is served by **RTU-16** located on roof. Per schedule from drawings reviewed unit is designed to provide adequate outside and is scheduled for 1,200 CFM minimum outside air.

2,088	sq.ft.	x	10	people/1,000 sq.ft.	=	20	people
2,088	sq.ft.	x	0.06	cfm/sq.ft.	=	125	cfm
20	people	x	20	cfm/person	=	400	cfm
Total	(rounded up to nearest 5)					525	cfm

Music Classrooms Ventilation Systems

Functionality & Current Operation

High School Music classrooms in Area E are ventilated by existing mixed air variable air volume roof top unit **RTU-17**. Per schedule from drawings reviewed unit is designed to provide adequate outside and is scheduled for 4,000 CFM minimum outside air.

5,345	sq.ft.	x	35	people/1,000 sq.ft.	=	187	people
5,345	sq.ft.	x	0.06	cfm/sq.ft.	=	321	cfm
187	people	x	10	cfm/person	=	1,870	cfm
Total	(rounded up to nearest 5)					2,195	cfm

Cafeteria and Kitchen Ventilation Systems

Functionality & Current Operation

High School Cafeteria is served by **RTU-7** located on roof above.

Outside Air Ventilation Rates

High School Cafeteria:

3,871	sq.ft.	x	100	people/1,000 sq.ft.	=	387	people
3,871	sq.ft.	x	0.18	cfm/sq.ft.	=	697	cfm
387	people	x	7.5	cfm/person	=	2,903	cfm
Total	(rounded up to nearest 5)					3,600	cfm

Cafeteria Servery area ventilation is exhaust driven at 0.7 CFM / square foot.

2,000 sq.ft. x 0.7 cfm/sq.ft. = 1,400 cfm

Unit provides outside air along with heating and cooling supply air. Schedule notes 8,500 CFM minimum outside air. Unit operates with demand control ventilation controlled by CO2 sensor located in space. Unit is capable of providing adequate outside air based on site survey and schedule review.

Total outside air provided by **RTU-7** provides adequate ventilation and make-up air for the High School cafeteria and Servery areas.

Auditorium and Stage Ventilation System

General Description & Operation

High School Auditorium and Stage is served by **RTU-18** located on low roof. Per schedule from drawings reviewed unit is designed to provide adequate outside and is scheduled for 6,750 CFM minimum outside air.

Outside Air Ventilation Rate

Auditorium Seating

8,057	sq.ft.	x 0.06cfm/sq.ft.	=	485	cfm
685	people x	5 cfm/person	=	3,428	cfm
Total	(rounded up to nearest 5)			3,910	cfm

Stage

2,165	sq.ft.	x 0.06cfm/sq.ft.	=	130	cfm
153	people x	5 cfm/person	=	152	cfm
Total	(rounded up to nearest 5)			285	cfm

Media Center Ventilation System

General Description & Operation

High School Media Center in Area H is ventilated by an existing mixed air variable air volume roof top unit, **RTU-30.** Unit appears to be undersized for current ventilation code. Current code required outside air is 3,015 CFM, existing units provides 11,200 CFM of supply air with minimum outside air not noted on drawings and schedules reviewed. Assuming 30% outside air this unit does provide code minimum ventilation. However though, unit is in poor condition and past its anticipated life expectancy. Unit should be considered for replacement with updated equipment that meets minimum ventilation requirements and energy code.

Media Center

12,616	sq.ft. x	25 people/1,000 sq.ft.	=	316	people
Override Population Per Facilities			=	150	people
12,616	sq.ft. x	0.12 cfm/sq.ft.	=	1,514	cfm
150	people x	10 cfm/person	=	1,500	cfm
Total	(rounded up to nearest 5)			3.015	cfm

Administration and Main Office Ventilation System

General Description & Operation

Administration offices in Area F, and G are heated, cooled, and ventilated by mixed air, **RTU-23, 24, 25, 26, and 27**. 1st floor Area J office and conference rooms are served by **RTU-31** and **RTU-33**. Typical offices range from 175 to 400 square feet. Conference rooms range from 200 – 400 square feet. Per schedules from drawings reviewed all units are designed to provide adequate outside with the exception of **RTU-26**.

Typical Offices

175	sq.ft.	x	5	people/1,000 sq.ft.	=	1	people
175	sq.ft.	x	0.06	cfm/sq.ft.	=	11	cfm
1	people	x	5	cfm/person	=	5	cfm
Total	(rounded up to nearest 5)					20	cfm

400	sq.ft.	x	5	people/1,000 sq.ft.	=	2	people
400	sq.ft.	x	0.06	cfm/sq.ft.	=	24	cfm
2	people	x	5	cfm/person	=	10	cfm
Total	(rounded up to nearest 5)					35	cfm

Reception Areas

881	sq.ft.	x	30	people/1,000 sq.ft.	=	27	people
881	sq.ft.	x	0.06	cfm/sq.ft.	=	53	cfm
27	people	x	5	cfm/person	=	135	cfm
Total	(rounded up to nearest 5)					190	cfm

Conference Rooms

200	sq.ft.	x	20	people/1,000 sq.ft.	=	4	people
200	sq.ft.	x	0.06	cfm/sq.ft.	=	12	cfm
4	people	x	5	cfm/person	=	20	cfm
Total	(rounded up to nearest 5)					35	cfm

400	sq.ft.	x	20	people/1,000 sq.ft.	=	8	people
400	sq.ft.	x	0.06	cfm/sq.ft.	=	24	cfm
8	people	x	5	cfm/person	=	40	cfm
Total	(rounded up to nearest 5)					65	cfm

Reception areas G130, G102, and G132 look to be under ventilated based on current code with **RTU-26** providing approximately 60 CFM of outside air to these spaces and current code requiring 190 CFM.

Nurse's Office Ventilation System

General Description & Operation

Nurse's office and adjacent rooms in Area F are heated, cooled, and ventilated by a mixed air roof top unit, **RTU- 22**.

400	sq.ft.	x	25	people/1,000 sq.ft.	=	10	people
400	sq.ft.	x	0.18	cfm/sq.ft.	=	72	cfm
10	people	x	10	cfm/person	=	100	cfm
Total	(rounded up to nearest 5)					175	cfm

Per drawings reviewed the following minimum outside air flowrates are listed for rooftop units noted.

HEATING, VENTILATION, AIR CONDITIONING UNIT SCHEDULE

UNIT NO.	TYPE MOUNTING	MFR.	MODEL NO.	CFM TOTAL	MIN. CFM O.A.	EXT. STATIC PRESSURE (IN W.G.)	FAN (HP)	VOLTS/PHASE/HERTZ	HEATING MBH (INPUT)	COOLING MBH	APPROXIMATE WEIGHT LBS	REMARKS
RTU-1	ROOF	TRANE	WJHB-204	8500	3450	2.0	7-1/2 1-1/2	460/3/60	460	---	6500	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-2	ROOF	TRANE	THC-060	2000	900	1.0	1/1	460/3/60	56	60	695	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 5 T COOLING EER 12.2
RTU-3	ROOF	TRANE	WJHB-40	14400	7800	2.0	10/3	460/3/60	900	---	3800	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-4	ROOF	TRANE	TSD060	8400	100%	2.0	10/3	460/3/60	408	---	420	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST
RTU-5	ROOF	TRANE	SLHFC-304	8400	6800	2.5	15/3	460/3/60	600	360	4800	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 30 T COOLING EER 9.7, VFD
RTU-6	ROOF	TRANE	TNC03	8800	7800	2.0	15/3	460/3/60	600	---	3636	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-7	ROOF	TRANE	SLHFC-404	16800	8900	2.5	20/3	460/3/60	770	480	3800	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 40 T COOLING EER 9.8, VFD
RTU-8	ROOF	TRANE	WJHB-204	6500	2000	3.0	10 1-1/2	460/3/60	560	---	8500	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-9	ROOF	TRANE	WJHB-204	5500	700	3.0	7-1/2 1-1/2	460/3/60	28	---	5710	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-10	ROOF	TRANE	TCP-180400	8128	3500	1.0	5/1	460/3/60	108	180	3358	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 15 T COOLING EER 11.5
RTU-11	ROOF	TRANE	TSD1008	5200	100%	1.0	5/3	460/3/60	280	---	3628	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST
RTU-12	ROOF	TRANE	WJHB-204	7800	2000	2.0	5 1-1/2	460/3/60	587	---	6500	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-13	ROOF	TRANE	WJHB-204	6000	2800	2.0	5 1-1/2	460/3/60	930	---	6270	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST, VFD
RTU-14	---	NOT USED	---	---	---	---	---	---	---	---	---	RTU-14 NOT USED
RTU-15	ROOF	TRANE	TCP180C40A	4850	1460	1.0	5/1	460/3/60	180	144	1820	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 10 T COOLING EER 11.5
RTU-16	ROOF	TRANE	TCP180C40A	4850	1200	1.0	5/1	460/3/60	124	180	1820	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 12.5 T COOLING EER 11.5
RTU-17	ROOF	TRANE	SLHFC204	10800	4000	2.5	15/3	460/3/60	480	300	6500	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 25 T COOLING EER 10.1, VFD
RTU-18	ROOF	TRANE	SLHFC304	20000	8750	2.5	25 7-1/2	460/3/60	970	400	9400	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 30 T COOLING EER 9.6, VFD
RTU-19	ROOF	TRANE	TSD060	4850	100%	1.0	7-1/2 3	460/3/60	587	---	5710	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST
RTU-20	ROOF	TRANE	WLHB204	7800	2000	2.0	5 1-1/2	460/3/60	587	---	6500	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST
RTU-21	ROOF	TRANE	TCP-120	4028	1200	.37	3/.75	208/3/60	240	120	---	EXISTING UNIT
RTU-22	ROOF	TRANE	TCP-120	4550	1250	.41	3/.75	208/3/60	172	179.4	---	EXISTING UNIT
RTU-23	ROOF	TRANE	TCP-150	4500	1500	.64	3/.75	208/3/60	110	140.7	---	EXISTING UNIT
RTU-24	ROOF	TRANE	TCP180C40C	8200	3150	1.0	7-1/2 .75	460/3/60	324	276	2258	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 24 T COOLING EER 11.6, VFD
RTU-25	ROOF	TRANE	TCP-074	3100	950	.38	1/.75	208/3/60	85	87.8	---	EXISTING UNIT
RTU-26	ROOF	TRANE	TCP-180	6400	870	.47	3/.75	208/3/60	204	172.8	---	EXISTING UNIT
RTU-27	ROOF	TRANE	TCP-036	2400	740	.38	1/.75	208/3/60	101	77.5	---	EXISTING UNIT
RTU-28	ROOF	TRANE	TSD060	4850	100%	1.0	7-1/2 3	460/3/60	110	---	3970	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST W/ HEAT WHEEL
RTU-29	ROOF	TRANE	TSD060	4879	100%	1.0	7-1/2 3	460/3/60	110	---	3882	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST W/ HEAT WHEEL
RTU-30	ROOF	CARRIER	---	1200	---	1.7	15/3	460/3/60	---	---	---	EXISTING UNIT
RTU-31	ROOF	TRANE	TCP-120	5228	880	.58	2/3	208/3/60	88/75	122.1	---	EXISTING UNIT
RTU-32	ROOF	TRANE	TCP-120	6000	1600	.49	2/3	208/3/60	168	120.8	---	EXISTING UNIT
RTU-33	ROOF	TRANE	TCP-241	6500	1650	.59	5/.75	208/3/60	54	241.5	---	EXISTING UNIT
RTU-34	ROOF	TRANE	TSD060	6000	100%	1.0	7-1/2 3	460/3/60	180	---	4484	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST W/ HEAT WHEEL
RTU-35	ROOF	TRANE	TSD060	6800	100%	1.0	5/10	460/3/60	180	---	4410	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST W/ HEAT WHEEL
RTU-36	ROOF	CARRIER	50PJ-024	8000	1600	1.7	15/3	460/3/60	---	---	---	EXISTING UNIT
RTU-37	ROOF	TRANE	TSD060	4500	100%	1.0	7-1/2 3	460/3/60	100	---	4098	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST W/ HEAT WHEEL
RTU-38	ROOF	TRANE	TSD060	4200	100%	1.0	5/3	460/3/60	100	---	4995	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST W/ HEAT WHEEL
RTU-39	ROOF	TRANE	TSH102A	4000	1200	1.0	5/1	460/3/60	128	120	900	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST 8 T COOLING
RTU-40	ROOF	TRANE	TSD060	3550	100%	1.0	5/10	460/3/60	250	---	4310	SEISMIC ROOF CURB HW HEATING COIL FILTERS ECON. OVERSIZED MOTOR EXHAUST
RTU-41	ROOF	CARRIER	34BE59	2550	8880	1.5	20	460/3/60	679	---	---	EXISTING UNIT
UV-1	FLOOR	TRANE	UVHB125	1250	450	---	1/4	277/1/60	128	---	499	HEATING COIL, FILTERS
UV-2	FLOOR	TRANE	UVHB150	1500	480	---	1/4	277/1/60	150	---	499	HEATING COIL, FILTERS
PTAC-1	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-2	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-3	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-4	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-5	CEILING	MITSUBISHI	PL12AK	340/420	---	---	144W	120/1/60	---	12,000	49	12000 MBH COOLING 9.9 EER
PTAC-6	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-7	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-8	WALL	MITSUBISHI	PK12FK	355	---	---	0.7	115/1/60	---	12,000	40	12000 MBH COOLING 11.9 SEER
PTAC-9	CEILING	MITSUBISHI	PL12AK	340/420	---	---	144W	120/1/60	---	12,000	49	12000 MBH COOLING 9.9 EER
CU-1	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-1 AND WINTER START CONTROL
CU-2	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-2 AND WINTER START CONTROL
CU-3	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-3 AND WINTER START CONTROL
CU-4	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-4 AND WINTER START CONTROL
CU-5	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-5 AND WINTER START CONTROL
CU-6	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-6 AND WINTER START CONTROL
CU-7	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-7 AND WINTER START CONTROL
CU-8	PAD	TRANE	TTA180	----	---	---	2 at 1/2	460/3/60	---	---	1550	CU-8 FOR RTU-8 OVERSIZED RS & EL PER MANUFACTURER 15 T
CU-9	PAD	TRANE	TTA090	----	---	---	1/2	460/3/60	---	---	489	CU-9 FOR RTU-9 OVERSIZED RS & EL PER MANUFACTURER 7-1/2 T
CU-10	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER MATCHED TO PTAC-8 AND WINTER START CONTROL
CU-11	PAD	MITSUBISHI	PU12FK	----	---	---	.65	208/1/60	---	---	110	OVERSIZED RS & EL PER MANUFACTURER TO PTAC-9 AND WINTER START CONTROL
AHU-1	HORIZ	TRANE	BCHB024	1500	400	.5	1/3	460/3/60	---	---	140	VERTICAL AHU HEATING ONLY

NOTES:

1. ALL UNITS SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
2. ALL RTU UNITS SHALL HAVE FLEXIBLE CANVAS CONNECTIONS ON DUCT INLETS AND OUTLETS.
3. THE CONTRACTOR SHALL PROVIDE ALL NECESSARY INTERFACING BETWEEN INDIVIDUAL UNITS AND AUTOMATIC TEMPERATURE CONTROL.
4. TRANSITION DUCTWORK ON INLET AND OUTLET OF EACH RTU UNIT TO MATCH SIZES ON PLANS.
5. COOLING CAPACITIES BASED UPON ARI STANDARDS 95 deg DB, 80 deg DB, 67 deg WB.
6. ALL AHU AND RTU UNITS SHALL BE PROVIDED WITH ALL ACCESSORIES INCLUDING BUT NOT LIMITED TO FULL MODULATING ECONOMIZER, POWER EXHAUST, OUTDOOR AIR DAMPERS, OVERSIZED MOTORS, COIL GUARDS, INSTALLATION KIT. UNITS SHALL BE PROVIDED WITH FILTERS.
7. PIPE CONDENSATE OF PTAC AS REQUIRED TO DRAIN. PROVIDE CONDENSATE PAN, LITTLE GIANT SHALLOW PAN.
8. PIPE CONDENSATE AS REQUIRED TO SPILL INDIRECTLY TO NEAREST SERVICE SINK. WIRE AND PIPE AS REQUESTED.
9. ALL AIRCONDITIONING UNITS TO UTILIZE HOT GAS BYPASS.
10. CUSTOM COLOR PAINT ALL UNITS. COLOR PER ARCHITECT.
11. ALL ROOFTOP UNITS TO BE PROVIDED WITH SUPPLY AND EXHAUST FANS.

Rooftop Unit Schedule

Summary & Recommendations

Short Term Recommendations -

1. Replace all filters in roof top air handling equipment with MERV 13 rated filters as capacity allows. Air handling unit shall be rebalanced to accommodate the added pressure drop through the MERV-13 filters. If MERV-13 filter cannot be used due to higher pressure drop provide MERV-11 filters.

Medium Term Recommendations -

1. Inspect, verify, and repair as needed all controls, unit ventilators, outside air dampers, and thermostats throughout building particularly for Classroom areas to ensure proper operation.

2. Implement normal mode and isolation mode for nurse's area to engage new dedicated exhaust fan and limit spreads of infectious aerosols throughout zone.

3. Furnish and install portable HEPA filtration unit for nurse's office and reception area.

Long Term Recommendations -

1. Provide replacement multi-zone variable air volume heating, cooling and ventilation roof top unit for **RTU-30**, with unit providing code minimum outside air and energy recovery for Media Center.

2. Due to age of equipment provide replacement multi-zone variable air volume heating, cooling and ventilation roof top unit for **RTU-21, 22, 23, 24, 25, 26, 30, 31, 32, and 33.**

Region 10 Middle School Ventilation Systems Assessment

Existing Conditions

Classroom Ventilation Systems

General Description & Operation

Classroom ventilation is primarily provided by unit ventilators throughout the school's first and second floor area A, K, L and M. Existing unit ventilators are top supply bottom face return and have a supply air fan, heating coil, and outside air/return damper. Temperature controls in classrooms is by digital thermostat.

Vocational classrooms in Area K are ventilated by mixed air roof top unit, **RTU-39**. Special Education and Nurse's office in Area L are ventilated by 100% outside air roof top unit **RTU-40**. RTU-39 provides heating, cooling, and ventilation air. Unit has a supply air fan, return/exhaust fan, heating coil, DX cooling coil, MERV-10 filters, and outside air damper. RTU-40 provides heating, and ventilation air only. Unit has a supply air fan, return/exhaust fan, heating coil, MERV-10 filters, and outside air damper.

Typical Packaged Roof Top Unit, RTU-39

East 2nd floor classrooms in Area M are ventilated by mixed air roof top unit, **RTU-36**. Unit provides heating, cooling, and ventilation air. Unit has a supply air fan, return/exhaust fan, heating coil, DX cooling coil, MERV-10 filters, and outside air damper.

Packaged Roof Top Unit, RTU-36

1st and 2nd floor Area K and M are ventilated by 100% outside air roof top units, **RTU-37 and RTU-38**. Unit are 100% outside air and provide heating, and ventilation air to core spaces (corridors, storage, bathrooms and locker rooms) in these areas and exhaust in classrooms to relieve ventilation air provided by unit ventilators. Units have a supply air fan, return/exhaust fan, heating coil, MERV-10 filters, and outside air damper.

100% Outside Air Unit, RTU-38

1st and 2nd floor Area M south wing classrooms are ventilated by mixed air roof top unit, **RTU-41**. Unit provides heating and ventilation air. Units have a supply air fan, return/exhaust fan, heating coil, MERV-10 filters, and outside air damper.

Packaged Roof Top Unit, RTU-41

Gymnasium Ventilation Systems

General Description & Operation

Middle School Gymnasium is served by single zone mixed air heating and ventilation only roof top unit, **RTU-3**. Unit includes supply fan, return fan, hot water heating coil, and MERV-10 filters. Exhaust air is provided by (2) roof mounted exhaust fans.

Middle School Gym Heating and Ventilation Unit, RTU-3

Middle School Auxiliary Gymnasium is served by single zone mixed air heating and ventilation only roof top unit, **RTU-1**. Unit includes supply fan, return fan, hot water heating coil, and MERV-10 filters. Exhaust air is provided by (2) roof mounted exhaust fans.

Middle School Locker Rooms are served by 100% outside air heating and ventilation only roof top unit, **RTU-4**. Unit includes supply fan, return fan, hot water heating coil, and MERV-10 filters.

Locker Rooms Heating and Ventilation Unit, RTU-4

Music Rooms Ventilation Systems

General Description & Operation

Middle School Music classrooms in Area C are ventilated by existing mixed air variable air volume roof top units, **RTU-8 and RTU-9.** Units include supply fan, return fan, hot water heating coil, and MERV-10 filters. Exhaust air is provided by (2) roof mounted exhaust fans.

Middle School Music Heating and Ventilation Units, RTU-8 and RTU-9

Fitness Room Ventilation Systems

General Description & Operation

Fitness Room is served by **RTU-2** located on roof. Units provides outside air along with heating and cooling supply air. System has a ducted supply and return with ceiling supply diffusers. Unit has MERV-10 filters.

Cafeteria and Kitchen Ventilation Systems

General Description & Operation

Middle School Cafeteria is served by **RTU-5** located on roof above. Unit provides outside air along with heating and cooling supply air. MERV-10 filters.

Middle School Cafeteria, RTU-5

Nurse's Office Ventilation System

General Description & Operation

Nurse's office L107 is heated and ventilated by 100% outside air roof top unit, **RTU- 40**. Unit provides outside air along with heating supply air. System has a ducted supply and return with ceiling supply diffusers and return grilles. Unit has MERV-10 filters.

100% Outside Air RTU-40

Control System

All systems are controlled by direct digital controls through Trane Tracer Building Management System. Thermostats are by Trane, flat front non-adjustable type thermostats in classrooms and adjustable thermostats with digital display in office areas.

Analysis

Classroom Ventilation Systems

Functionality & Current Operation

Classrooms ventilation is primarily provided by unit ventilators, **UV-1 and UV-2**, throughout the school's first and second floor area A, K, L and M. Unit ventilators are in fair to good shape. Units are designed to function as both heating and ventilation source. Units are capable of providing adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 450 CFM.

Typical classroom is approximately 680 square feet.

680	sq.ft.	x	35	people/1,000 sq.ft.	=	24	people
680	sq.ft.	x	0.12	cfm/sq.ft.	=	82	cfm
24	people	x	10	cfm/person	=	240	cfm
Total	(rounded up to nearest 5)					325	cfm

Vocational classrooms in Area K are ventilated by mixed air roof top unit, **RTU-39**. Unit is in fair condition. Units provides adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 1200 CFM.

Woodshop

935	sq.ft.	x	20	people/1,000 sq.ft.	=	19	people
935	sq.ft.	x	0.18	cfm/sq.ft.	=	169	cfm
19	people	x	10	cfm/person	=	190	cfm
Total	(rounded up to nearest 5)					340	cfm

Education Technology

698	sq.ft.	x	35	people/1,000 sq.ft.	=	25	people
698	sq.ft.	x	0.12	cfm/sq.ft.	=	84	cfm
25	people	x	10	cfm/person	=	250	cfm
Total	(rounded up to nearest 5)					335	cfm

East 2nd floor classrooms in Area M are ventilated by mixed air roof top unit, **RTU-36**. Unit is in poor condition and was an existing unit reused during the 2005 renovations project. Units does not provide adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 1600 CFM and total supply air of 9,000 CFM. Special Education classroom M225 requires 445 CFM of outside air and only receives approximately 242 CFM based on VAV36-6 maximum flow rate.

Special Education

940	sq.ft.	x	35	people/1,000 sq.ft.	=	33	people
940	sq.ft.	x	0.12	cfm/sq.ft.	=	113	cfm
33	people	x	10	cfm/person	=	330	cfm
Total	(rounded up to nearest 5)					445	cfm

1st and 2nd floor Area K and M are ventilated by 100% outside air roof top units, **RTU-37 and RTU-38**. Unit are 100% outside air and provide heating, and ventilation air to core spaces (corridors, storage, and bathrooms) in these areas and exhaust in classrooms to relieve ventilation air provided by unit ventilators. Units is capable of providing adequate outside air and exhaust based on site survey and schedules reviewed noting a minimum outside air flow of 4500 and 4200 CFM respectively. Classroom M114 and M112 are under ventilated based on code occupancy noted below with each room being provided with 150 CFM of outside air per drawings reviewed. Rooms should be renovated and balanced to provide code required ventilation.

Typical Classrooms

831	sq.ft.	x	35	people/1,000 sq.ft.	=	29	people
831	sq.ft.	x	0.12	cfm/sq.ft.	=	100	cfm
29	people	x	10	cfm/person	=	290	cfm
Total	(rounded up to nearest 5)					390	cfm

Art Classrooms

1,492	sq.ft.	x	20	people/1,000 sq.ft.	=	30	people
1,492	sq.ft.	x	0.18	cfm/sq.ft.	=	269	cfm
30	people	x	10	cfm/person	=	300	cfm
Total	(rounded up to nearest 5)					570	cfm

Classroom - M114

586	sq.ft.	x	35	people/1,000 sq.ft.	=	21	people
586	sq.ft.	x	0.12	cfm/sq.ft.	=	71	cfm
21	people	x	10	cfm/person	=	210	cfm
Total	(rounded up to nearest 5)					285	cfm

1st and 2nd floor Area M south wing classrooms are ventilated by mixed air roof top unit, **RTU-41**. Unit is in poor condition and was an existing unit reused during the 2005 renovations project. Unit may provide adequate outside air based on site survey and schedules reviewed noting a minimum outside air flow of 8,650 CFM and total supply air of 23,150 CFM. Measurements are needed to verify as existing drawings do not provide airflow data in this area.

Science Classrooms

1,074	sq.ft.	x	25	people/1,000 sq.ft.	=	27	people
1,074	sq.ft.	x	0.18	cfm/sq.ft.	=	193	cfm
27	people	x	10	cfm/person	=	270	cfm
Total	(rounded up to nearest 5)					465	cfm

Gymnasium Ventilation Systems

Functionality & Current Operation

Middle School Gymnasium is served by single zone mixed air heating and ventilation only roof top unit, **RTU-3**. Middle School Auxiliary Gymnasium is served by single zone mixed air heating and ventilation only roof top unit, **RTU-1**. Both units operate with demand control ventilation controlled by CO2 sensors located in the space and provide adequate outside air based on site survey and schedules reviewed. It was observed during site visit that exterior duct insulation on RTU-3 was failing off due to moisture penetration and should be repaired.

Main Gymnasium - Non-Spectator Area

6,238	sq.ft.	x	0.30	cfm/sq.ft.	=	1,875	cfm

Auxiliary Gymnasium - Non-Spectator Area

3,488	sq.ft.	x	0.30	cfm/sq.ft.	=	1,050	cfm

Main Gymnasium - Spectator Area

135	sq.ft.	x	150	people/1,000 sq.ft.	=	20	people
135	sq.ft.	x	0.06	cfm/sq.ft.	=	8	cfm
20	people	x	7.5	cfm/person	=	150	cfm
Total	(rounded up to nearest 5)					160	cfm

Middle School Locker Rooms are served by 100% outside air heating and ventilation only roof top unit, **RTU-4**. Locker rooms are exhaust driven at 0.5 CFM/square foot. Unit provides adequate ventilation are based on site observation and schedules reviewed.

Locker Rooms

3,018	sq.ft.	x	0.50 CFM	=	1,510	CFM

Fitness Rooms Ventilation Systems

Functionality & Current Operation

Fitness Room is served by **RTU-2** located on roof above. Per schedule from drawings reviewed unit is designed to provide adequate outside and is scheduled for 500 CFM minimum outside air.

912	sq.ft.	x	10	people/1,000 sq.ft.	=	19	people
912	sq.ft.	x	0.06	cfm/sq.ft.	=	55	cfm
19	people	x	20	cfm/person	=	380	cfm
Total	(rounded up to nearest 5)					435	cfm

Music Classrooms Ventilation Systems

Functionality & Current Operation

Middle School Music classrooms in Area C are ventilated by existing mixed air variable air volume roof top units, **RTU-8 and RTU-9.** Per schedule from drawings reviewed **RTU-8** provides adequate outside air to Instrumental room C114.

Per schedule from drawings reviewed **RTU-9** does not provide adequate outside and is scheduled for 700 CFM minimum outside air with 3,500 CFM supply air (20 % OA). At 20% outside air the choral room C125, C126 and Music room C127 are under ventilated per code requirements.

Music – C125

408	sq.ft.	x	35	people/1,000 sq.ft.	=	15	people
408	sq.ft.	x	0.06	cfm/sq.ft.	=	25	cfm
15	people	x	10	cfm/person	=	150	cfm
Total	(rounded up to nearest 5)					175	cfm

Choral – C126

1,292	sq.ft.	x	35	people/1,000 sq.ft.	=	46	people
1,292	sq.ft.	x	0.06	cfm/sq.ft.	=	78	cfm
46	people	x	10	cfm/person	=	460	cfm
Total	(rounded up to nearest 5)					540	cfm

Music – C127

533	sq.ft.	x	35	people/1,000 sq.ft.	=	19	people
533	sq.ft.	x	0.06	cfm/sq.ft.	=	32	cfm
19	people	x	10	cfm/person	=	190	cfm
Total	(rounded up to nearest 5)					225	cfm

Instrumental

3,091	sq.ft.	x	35	people/1,000 sq.ft.	=	109	people
3,091	sq.ft.	x	0.06	cfm/sq.ft.	=	186	cfm
109	people	x	10	cfm/person	=	1090	cfm
Total	(rounded up to nearest 5)					1,280	cfm

Cafeteria and Kitchen Ventilation Systems

Functionality & Current Operation

Middle School Cafeteria is served by **RTU-5** located on roof above.

Outside Air Ventilation Rates

Middle School Cafeteria:

4,622	sq.ft.	x	100	people/1,000 sq.ft.	=	463	people
4,622	sq.ft.	x	0.18	cfm/sq.ft.	=	832	cfm
463	people	x	7.5	cfm/person	=	3,473	cfm
Total	(rounded up to nearest 5)					4,305	cfm

Total outside air provided by **RTU-5** provides adequate ventilation to the Middle School Cafeteria.

Nurse's Office Ventilation System

General Description & Operation

Nurse's office L107 is heated and ventilated by 100% outside air roof top unit, **RTU-40**. Per drawings reviewed the following minimum outside air flowrates are listed for rooftop units noted.

Summary & Recommendations

Short Term Recommendations -

1. Verify airflow and outside air for all classrooms in Area M ventilated by RTU-41. Inspect and verify airflow at unit along with operation.

2. Provide higher exhaust air than supply air for nurse's office, balance to 375 CFM supply air, 425 CFM return air to keep negative pressure.

3. Replace all filters in roof top air handling equipment with MERV 13 rated filters as capacity allows. Air handling unit shall be rebalanced to accommodate the added pressure drop through the MERV-13 filters. If MERV-13 filter cannot be used due to higher pressure drop provide MERV-11 filters.

4. Repair exterior insulation and cladding on RTU-3 roof ductwork.

Medium Term Recommendations -

5. Inspect, verify, and repair as needed all controls, unit ventilators, outside air dampers, and thermostats throughout building particularly for Classroom areas.

6. Provide classrooms M114 and M112 with code required ventilation.

7. Implement normal mode and isolation mode for nurse's office.

8. Furnish and install portable HEPA filtration unit for nurse's office.

Long Term Recommendations -

9. Provide replacement multi-zone variable air volume heating, cooling and ventilation roof top unit for **RTU-36,** with unit providing code minimum outside air and energy recovery for Area M.

10. Provide replacement to **RTU-9** to provide minimum outside air required by code to Music and Choral rooms.

11. Due to age of equipment provide replacement multi-zone variable air volume heating, cooling and ventilation roof top unit for **RTU-36 and 41.**

CX Executive Summary

Overview

Following the in-depth review and testing of equipment components pertaining to building ventilation systems, corrections to deficiencies identified and adjustments considered to confirm operation of ventilation equipment and systems. While the district is working to correct issues in the short term, from a commissioning standpoint, the above mentioned recommendations are agreed upon between the commissioning and engineering teams.

Objectives and Goals

Objectives

The intent of this process was to review building elements and systems pertaining to ventilation to ensure that they are operating properly.

Goals

1. Confirm capabilities of outside air ventilation by temporarily simulating conditions for verification of out door air dampers and fan operation.
2. Assist with suggestions for tuning ventilation systems to enable them to perform at the maximum capacity consistent with full occupancy conditions for the building.
3. Assist with suggestions for adequate filtration.

Project description and summary of scope of work

CES provided commissioning services for all of the HVAC systems as it pertains to Ventilation including:

- Scope Task: Identify building systems and associated capabilities.
- Scope Task: Identify systems and associated controls are operating properly as they pertains to ventilation and provide suggestions where controls adjustments can be made. This would include rooftop units, variable air volume review, and exhaust fans, fan coil units with outside air and unit ventilators.
- Scope Task: Review schedule parameters and provide recommendations for adjustments where needed.
- Scope Task: Where necessary, inspect and verify all automated setpoints including CO2 and temperature.
- Scope Task: Filters and Frames - Confirm clean filters are in place and associated racks are in good condition.
- Scope Task: Dampers and associated actuators: Provide visual inspection where possible of control dampers to ensure integrity of ventilation to the spaces.

Schools Assessed

- Region 10 High School, 24 Lyon Road, Burlington
- Region 10 Middle School, 24 Lyon Road, Burlington

Systems Commissioned

1. HVAC equipment operation and controls as it pertains to Ventilation
2. Rooftop Units
3. VAV Boxes
4. Exhaust Fans
5. Unit Ventilators
6. Fan Coil Units
7. Associated Dampers
8. Filters - cleanliness
9. BMS Schedules

Commissioning Process

The Commissioning Team utilized a combination of remote review of systems for performance as well as visual inspections to ensure that the schools are being properly ventilated. In an effort to do so, we reviewed the following: Rooftop Units, VAV Boxes, Unit Ventilators, Exhaust Fans and Fan Coil Units. This equipment was reviewed for this assessment as this equipment is a part of ventilation of spaces which brings in outside air or exhausting air out of the building. Working both on our own and directly with the facilities staff, we reviewed and tested all associated equipment in each school to confirm the following:

All issues were reported directly to the facilities staff and have all since been fully addressed.

- Supply Fan command and status was reviewed remotely through the building management system and actual fan status was reviewed through visual onsite inspection.
- Damper commands and status was reviewed remotely through the building management system and actual damper position was reviewed through visual onsite inspection.
- Exhaust Fan command and status was reviewed remotely through the building management system and actual fan status was reviewed through visual onsite inspection.
- Where demand control ventilation is provided as a part of the sequence of operation, it was reviewed and confirmed onsite.
- Filter rack and associated filters were reviewed for condition and all issues were reported directly to the facilities staff.

Appendix A - Outside Air Ventilation Tables

The International Mechanical Code (IMC)/ASHRAE 62.1 requirements for outside air ventilation are based on student/occupant densities that may not be applicable for some, if not many, of the spaces in this school, as the school/school district may, for the purposes of reducing the probability of the transmitting viruses, use student/occupant densities that are less than the prescribed student/occupant densities in the IMC/ASHRAE 62.1. For such spaces the required outside air ventilation rates would be less than outside air ventilation rates calculated using the prescribed student/occupant densities in the IMC/ASHRAE 62.1. The Appendix A tables are used for determining the required outside air ventilation for such spaces.

Table A-1: Typical Classrooms

Table A-2: Art Classrooms, Science Classrooms, & Shop Classrooms

Table A-3: Music Classrooms, Theater Classrooms, & Dance Classrooms

Table A-4: Lecture Classrooms & Multiuse Assembly Spaces

Table A-5: Media Centers

Table A-6: Exercise Rooms (Aerobics, Weights)

Table A-7: Cafeterias

Table A-8: Office Areas, Conference Rooms, & Staff Workrooms

Gymnasiums: The IMC/ASHRAE 62.1 requires 0.3 cfm/sq.ft. of outside air ventilation for gymnasiums (non-spectator areas); there are no per person outside air ventilation requirements for gymnasiums. As therefore the outside airflow calculation for gymnasiums is simple, a table for outside air ventilation for gymnasiums is not included. Where gymnasiums are used with spectators, the outside air ventilation required for the non-spectator areas should be added to the outside air ventilation required for the spectator areas. The IMC/ASHRAE 62.1 outside air ventilation requirements for spectator areas of gymnasiums is 7.5 cfm/person + 0.06 cfm/sq.ft., and the IMC/ASHRAE 62.1 prescribed occupancy density for spectator areas is 150 people/1,000 sq.ft. Preferably, for a gymnasium where the spectator areas are only occasionally used, which would be typical for public schools, the HVAC system serving the gymnasium should be provided with demand control ventilation (modulating the outside air ventilation to maintain acceptable CO^2 level). A recommended option for activation of the demand control ventilation is a timer type switch in the gymnasium, where when the switch is activated the demand control ventilation mode operates for several hours and they reverts back to normal occupied/unoccupied mode.

Corridors: The IMC/ASHRAE 62.1 requires 0.06 cfm/sq.ft. of outside air ventilation for corridors; there are no per person outside air ventilation requirements for corridors. As therefore the outside airflow calculation for corridors is simple, a table for outside air ventilation for corridors is not included.

Appendix B – CX Master Deficiency and Resolution Log

See attached.