



IAQ Verification Report

Nathan Hale Arts Magnet School

New London, CT

SES Project No. 24-461

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Table of Contents

Executive Summary	1
IAQ Verification Process.....	1
<i>Filter Evaluation</i>	1
<i>Ventilation Evaluation</i>	1
<i>Demand Control Ventilation</i>	2
Project Approach.....	2
Participants.....	4
Facility Description	5
<i>Building</i>	5
<i>Occupancy</i>	5
<i>Building Automation System Description</i>	5
<i>HVAC Systems Description</i>	5
<i>Rooftop Units</i>	5
<i>Air Handling Units</i>	6
Recommendations.....	7
<i>Initial Recommendations</i>	7
<i>Recommendation #1: Recalibrate VAV's Associated With RTU-1A, 1B, 2 & 3 and AHU-2</i>	7
<i>Recommendation #2: Rebalance RTU-1A, 1B, 2 & 3 To New Minimum Outside Air Damper Positions</i>	7
<i>Recommendation #3: Investigate Damper Operations For AHU-1</i>	8
<i>Recommendation #4: Filter Improvements</i>	8
<i>Recommendation #5: Replace Return Air CO2 Sensor For AHU-1</i>	8
<i>Recommendation #6: Investigate/Rebalance Exhaust Fan/s</i>	8
Additional Findings.....	9
<i>Finding #1: Install Demand Control Ventilation in VAV Zones For RTU-1A, 1B, 2 & 3</i>	9
Next Steps	10
<i>Review Recommendations</i>	10

Appendix A IAQ Evaluation Sheet

Appendix B International Mechanical Code Minimum Ventilation Rates (2021) per ASHRAE 62.1



Executive Summary

Sustainable Engineering Solutions, LLC (SES) and Trueflow Testing and Balancing were retained by the Town of New London to provide professional engineering and test and balancing (TAB) services to meet the indoor air quality (IAQ) verification requirements of the state legislation Public Act No. 23-167 at the Nathan Hale Elementary School facility. This combined effort successfully completed the required verification as outlined in the legislation. With a focus on validating and improving indoor air quality, SES and Trueflow systematically assessed each air handling system to measure current ventilation rates, filtration rates and distribution levels compared to current ventilation standards.

Although the requirements have been met for some of the equipment in the building, utilizing operable windows as the primary means of ventilation is not recommended due to poor temperature control. Recommendations associated with the buildings air handling units, roof top units and exhaust fans, along with an additional finding, have been included in this report for the Client to review.

Overall, the HVAC air handling systems were found to be in good condition and have been well maintained. The survey identified zones with ventilation below required levels, primarily due to mechanical issues with VAV controllers and calibration. Addressing these VAV issues, rebalancing outside air levels for RTUs, and adjustments to EF are recommended.

Note that throughout this report the term “ventilation” air and “outside” are used interchangeably and are one in the same.

IAQ Verification Process

Filter Evaluation

As required by the law, the team reviewed the current level of filtration installed on each air handling system and analyzed the feasibility of increasing the filter ratings to MERV 13. A filter’s minimum efficiency reporting value, or MERV, is a rating system that measures how efficient a filter is at trapping harmful particulate matter, dust, and debris in the air. This rating system categorizes filters into a ranking from 2 to 20, with a MERV 8 being the standard. A higher MERV rating means that a filter is more efficient and MERV 13 is recommended for many commercial and industrial buildings and by state code. At its minimum, a MERV 13 filter traps less than 75% of air particles that are 0.3 to 1.0 microns in size and is at least 90% effective when the particles increase to 3 to 10 microns in size. Along with assessing the filter efficiencies, the condition of unit’s filters and proper sealing of the filter banks to eliminate bypass air was also evaluated.

Ventilation Evaluation

The amount of ventilation air delivered into interior occupied spaces is governed by the 2022 Connecticut State Building Code, which references ASHRAE Standard 62.1. This code prescribes the flow rate of ventilation air that must be supplied mechanically, or otherwise, to occupied areas based on occupancy classifications. Depending on the type of use of a space and total space area, outdoor air flow rates in cubic feet per minute (CFM) per person and square foot are defined when the



parameters are known. When total occupants per space are unknown, the code defines occupant density for each classification type in number of occupants per space floor area. The final flow rate in CFM for every occupied space can thus be calculated.

As an alternative to providing outside air mechanically to occupied spaces, the building code also allows for outside air to enter occupied areas naturally through operable windows. If the area of operable windows for an occupied space is at least 4% of the space's floor area, mechanical ventilation for that space is not required by code. However, although spaces with sufficient operable window area may satisfy code requirements, this is not a realistic way of providing adequate ventilation during periods of cold or hot weather.

The amount of outside air supplied to occupied spaces is important for occupant comfort and health because contaminants generated by people and materials in the space must be removed or they will build up to unhealthy levels. Diluting interior air with outside air reduces the concentration of carbon dioxide, volatile organic compounds (VOCs) along with various airborne viral and bacterial contaminants.

Demand Control Ventilation

In certain applications, the amount of outside air delivered to a space can be reduced if occupancy and indoor air quality can be safely monitored and controlled. This is most typically accomplished through monitoring carbon dioxide (CO₂) and occupancy sensors in the space, otherwise known as "Demand Control Ventilation" or DCV. As occupancy rises in a space, so does the amount of CO₂ as a result of the occupant's natural respiration and exhalation of CO₂. By monitoring CO₂ and occupancy status, an HVAC system can reduce the amount of outside air to a zone when levels and occupancy are low. If CO₂ levels rise above a certain threshold or occupancy is detected, the HVAC system can then increase the amount of fresh air until the levels fall back below an acceptable level. Having an operational demand control ventilation strategy in place will help reduce energy consumption of a facility while simultaneously ensuring all spaces are achieving the required fresh air requirements.

Project Approach

During the review of the school, SES took the following steps to complete the study:

- Develop an IAQ evaluation plan and conduct a kickoff meeting with the client and Trueflow to review the plan, project schedule, access, etc.
- Perform a walkthrough of the building to review the HVAC systems providing ventilation air for a condition assessment of the systems and understand any maintenance issues that may be related.
- Review available documentation for the HVAC systems that includes:
 - As-built drawings or original design drawings
 - O&M documentation for systems performance data



- Review any previous testing adjusting and balancing reports from the HVAC systems
- Review documentation describing the chronology of known problems, system failures, complaints, and alterations.
- Develop IAQ evaluation documentation for field evaluation of equipment.
- Perform field evaluation of equipment for ventilation sequence of operation and verify calibration of CO2 sensors where used (+/- 50 PPM).
- Review Trueflow's completed ventilation rate verification sheets for each space for compliance with ASHRAE 62.1
- Review the Trueflow's completed unit data sheets for each system providing ventilation air for ventilation airflows, filter condition and efficiency, damper conditions and maintenance adequacy.
- Prepare a report that summarizes the verification process, identifies any deficiencies that require correction and any recommendations to address the deficiencies found and next steps.



Participants

The participants in the IAQ verification process for this project are identified below.

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Facility Description

Building

Building:	Nathan Hale Arts Magnet School
Location:	37 Beech Dr, New London, CT
Building Size (gross):	95,000 ft ²
Year Constructed:	2003 (Renovation)
Building Use (current):	Education



The 95,000 square foot Nathan Hale Arts Magnet School building had its existing 26,000 square foot school renovated and new 69,000 square foot addition construction in 2003. The school provides a learning space for kindergarten through 5th grade. The building consists of classrooms, administration offices, gymnasium, cafeteria, media center and other typical educational spaces.

Occupancy

The building is occupied Monday through Friday between 7 a.m. and 3 p.m. Special events are held on the weekends and after hours as needed for school extracurricular activities. In addition, the school hosts summer school activities during the summer break.

Building Automation System Description

The HVAC system is controlled by a building automation system. This system has graphics for all the HVAC equipment and is capable of trending and performing custom control algorithms.

HVAC Systems Description

Rooftop Units

In total, there are five (5) rooftop units (RTUs) in the facility. Four units are multizone variable-air-volume (VAV) units that serve multiple VAV box zones. RTU-4 is a single-zone variable-air-volume (VAV). The rooftop units are approximately 10 years old and connected to the building automation system.



For the multizone VAV RTUs, airflow to the space is controlled by the VAV box with ventilation air being provided and controlled by the RTU. As the heating and cooling requirements of the space change, the VAVs adjust the total airflow introduced in the space. The air entering the VAV box is served by the associated rooftop unit. The rooftop unit mixes return air from the building with fresh outside air, filters the airstream and then conditions it by heating or cooling as necessary. As the airflow requirements of the spaces change, the supply fan of the unit will increase and decrease speed accordingly.

For the single zone air handling units, the spaces are conditioned and ventilated by the associated unit. The unit mixes return air from the space with fresh outside air, filters the airstream and then conditions it by heating or cooling as necessary at a constant airflow. As the space requires cooling and heating, the RTU supply fan will modulate speed between a minimum and a maximum setpoint.

All RTUs maintain a fixed minimum outside air damper setpoint but are equipped with return air carbon dioxide (CO₂) sensors for demand control ventilation. As the CO₂ in the building rises above the RTUs setpoint, the outside air damper will modulate from minimum setpoint to 100% open. Once CO₂ levels fall below setpoint, the outside air damper will modulate back towards minimum position.

Unit Tag	Serves	Type	Min OA Damper Setpoint	CO ₂ Setpoint
RTU-1A	East Wing	Multizone VAV	20%	800 PPM
RTU-1B	Center Wing	Multizone VAV	20%	800 PPM
RTU-2	West Wing	Multizone VAV	20%	800 PPM
RTU-3	Offices & Classrooms	Multizone VAV	20%	800 PPM
RTU-4	Gymnasium	Single-Zone VAV	20%	800 PPM

Air Handling Units

Three air handling units are installed in the mechanical room. The air handling units appear to be approximately 10 years old and are connected to the building management system. The air handling units appear to be single-zone VAV units providing variable speed and conditioned air to the spaces each unit serves.

Unit Tag	Serves	Type	Min OA Damper Setpoint	CO ₂ Setpoint
AHU-1	Cafeteria	Single-Zone VAV	20%	800 PPM
AHU-2	Center Wing	Multi-Zone VAV	20%	800 PPM
AHU-3	Lobby	Single-Zone VAV	20%	800 PPM



Recommendations

The following recommendations were made based on the review of TAB report, ventilation comparisons to the IMC Minimum Ventilation Rates (2021) and industry best practices. Additional supporting information can be found in the Appendices of the report.

Due to the limited area of focus of the required IAQ verification and this review, SES strongly recommends verifying the condition of all related HVAC equipment components and control functionality outside of the scope of this verification, prior to implementing any modifications to the HVAC systems.

Initial Recommendations

- Recommendation #1: Recalibrate VAV's Associated With RTU-1A, 1B, 2 & 3 and AHU-2
- Recommendation #2: Rebalance RTU-1A, 1B, 2 & 3 To New Minimum Outside Air Damper Positions
- Recommendation #3: Investigate Damper Operations For AHU-1
- Recommendation #4: Filter Improvements
- Recommendation #5: Replace Return Air CO2 Sensor For AHU-1
- Recommendation #6: Investigate/Rebalance Exhaust Fan/s

Recommendation #1: Recalibrate VAV's Associated With RTU-1A, 1B, 2 & 3 and AHU-2

During testing, adjusting, and balancing it was determined that the majority of the VAV boxes are out of calibration and unable to control to their airflow setpoints. VAV boxes that are considered to be out of calibration showed uncalibrated airflow stations, symptoms of this included BMS airflow readings not matching with field measured values by TAB contractor and BMS airflow readings and/or field measured values not satisfying specified airflow setpoints. Although some of the spaces that do not meet airflow requirements have operable windows, operable windows are not a recommended means of ventilation due to the need to manually open windows to properly ventilate spaces and the unpredictability of outside air conditions.

SES recommends recalibrating all VAV boxes so that they can properly maintain the associated airflow setpoints. In the event VAV controllers are failed or inoperable they should be replaced.

Recommendation #2: Rebalance RTU-1A, 1B, 2 & 3 To New Minimum Outside Air Damper Positions

In review of the TAB data, the following roof top units and spaces served do not meet minimum ventilation requirements when under occupied conditions. Units control demand control ventilation mode based on return air CO2, all space's occupancy conditions are not currently monitored.



The outside air airflow for the following roof top units should be re-balanced to the values shown in the table below and an outside air damper position determined associated with the new calculated minimum outside airflow setpoints. Under normal conditions, the RTUs shall be at their new fixed minimum outside air position.

Unit Tag	Served	Measured Outside Airflow (CFM)	Calculated Required Minimum Outside Airflow (CFM)
RTU-1A	001-009, 145-153 & 201-209	4,465	5,450
RTU-1B	157-168 & 213-226	2,006	4,620
RTU-2	173-179 & 227-249	1,796	3,720
RTU-3	115-142	311	740

Recommendation #3: Investigate Damper Operations For AHU-1

During TAB measurements, dampers for AHU-1 were modulating without any calls for economizer or demand control ventilation. Because of this, accurate testing and balancing readings could not be collected for this unit. It is recommended that dampers for this unit are reviewed to ensure their physical condition is operational and programming is in place for proper operation.

Recommendation #4: Filter Improvements

Currently AHU-3 was found to have dirty filters. SES recommends replacing filters to ensure maximum filtration efficiency. Filters in building are already MERV-13.

Recommendation #5: Replace Return Air CO2 Sensor For AHU-1

During survey, the return air CO2 sensor for AHU-1 was found to be reading 9 ppm.

Sensor should be replaced to ensure programmed demand control ventilation operates per programming.

Recommendation #6: Investigate/Rebalance Exhaust Fan/s

The following spaces were found to be below their calculated exhaust air requirements. SES recommends that the spaces and associated ductwork are reviewed for proper connection and exhaust outlet rebalanced as needed. If spaces remain low on exhaust, associated exhaust fan and operation should be reviewed.

Space	TAB Measured Exhaust CFM	Calculated Exhaust CFM
Classroom 78 Bathroom	0	25
Faculty BR	0	25
Girls BR across rm 237	38	75
Boys BR across rm 239	39	75



Additional Findings

In addition to the above-mentioned recommendations specific to the focus of this program, SES has identified the following operational deficiencies that we recommend are further reviewed and possibly implemented.

Finding #1: Install Demand Control Ventilation in VAV Zones For RTU-1A, 1B, 2 & 3

In review of the TAB data, the majority of VAV zones were found to not meet minimum ventilation requirements without operable windows.

While the majority of the spaces satisfied the code required ventilation rates, this was largely due to having operable windows. Operable windows are allowable means of ventilation per code, however are not recommended as they typically result in overheating or overcooling of the space. This method of ventilation also requires the occupants to open the windows when in the space which typically does not occur.

SES recommends implementing the following demand control ventilation programming into the VAV zones as a result. The modified programming will ensure the required ventilation rates are satisfied based on the zone specific requirements without relying on operable windows:

1. A space CO₂ sensor will be installed in each VAV zone (93 total).
2. Under normal operation, the VAV airflow setpoint will remain at minimum and increase to maximum based on the higher of space temperature or space CO₂. Existing space temperature control remains unchanged.
3. If space CO₂ exceeds the setpoint (900 ppm, adj.), the VAV will modulate open toward the maximum airflow setpoint until it is reached. If CO₂ remains above setpoint for more than 1 hour (adj.) while the VAV is at maximum airflow, the associated AHU will receive a flag for increased ventilation.
4. Under normal conditions, the associated AHU operates at the minimum outside air damper position (MIN-OAD). When a flag for increased ventilation is received, the outside air damper modulates to the maximum position (MAX-OAD), subject to a low mixed air temperature limit of 50°F (adj.). Once the high CO₂ flag is cleared, the damper returns to MIN-OAD.
5. TAB contractor shall determine new MIN-OAD and MAX-OAD damper setpoints that correspond to the airflows listed in the table below.

Unit Tag	MIN-OAD (CFM)	MAX-OAD (CFM)
RTU-1A	1,440	5,450
RTU-1B	1,590	4,620
RTU-2	1,110	3,720
RTU-3	280	740



Next Steps

Review Recommendations

It is recommended that the client review this report and the proposed recommendations for further clarification, if needed and decide a course of action. SES can provide additional assistance if needed, to further analyze and develop these recommendations for future implementation, and if desired, provide commissioning of the implemented measures.



Appendix A: IAQ Evaluation Sheet

Tag	AREA SERVED	Type	Filters (1 = clean, 2 = partially loaded, 3 = dirty)		Unit Condition	Outside Air Control Method	CO2 Control?	TAB Measured			Summated OA Airflow	Calculated Min. Outside Airflow	% OA2	Comments
			Pre-Filter Condition	Final Filter Conditon				Supply Airflow	Min. Outside Airflow3	% OA				
RTU-1A	001-009, 145-153 & 201-209	Multi-Zone VAV	1	1	Fair	Fixed Minimum	Yes	12,412	4,465	36%	5,441	5,450	44%	
RTU-1B	157-168 & 213-226	Multi-Zone VAV	1	1	Good	Fixed Minimum	Yes	7,069	2,006	28%	4,611	4,620	65%	
RTU-2	173-179 & 227-249	Multi-Zone VAV	1	1	Good	Fixed Minimum	Yes	6,695	1,796	27%	3,715	3,720	56%	
RTU-3	115-142	Multi-Zone VAV	1	1	Good	Fixed Minimum	Yes	3,119	311	10%	738	740	24%	
RTU-4	Gymnasium	Single Zone VAV	1	1	Good	Fixed Minimum	Yes	3,989	764	19%	3,824	3,830	96%	
AHU-1	Cafeteria	Single Zone VAV	1	1	Good	Fixed Minimum	Yes			#DIV/0!	-	-	#DIV/0!	Readings could not be collected for unit due to inconsistent damper operation.
AHU-2	Dance Studio, Custodian office & Computer lab 5	Multi-Zone VAV	1	1	Good	Fixed Minimum	Yes	3,833	1,406	37%	782	790	21%	
AHU-3	Lobby	Single Zone VAV	1	3	Good	Fixed Minimum	Yes	3,148	1,159	37%	359	360	11%	

IMC 2021 Ventilation Assessment

Unit Tag	Room #	Category	Infiltration	ZoneArea, Az, per space (SF)	Zone Population, Pz, per space	People OA Rate in Breathing Zone, Rp (CFM/person)	Area OA Rate in Breathing Zone, Ra (CFM/SF)	Default Occupant Density	Breathing Zone OA (CFM) Vbz=RpPz+RaAz	Table 6-2 Zone Air Distribution Effectiveness	Zone OA Flow, Voz	Min. Ventilation Airflow (CFM)	Actual Supply Airflow (CFM)	% OA	Actual Ventilation Airflow (CFM)	Ventilation Difference (CFM)	Ventilation Difference (%)	Code Satisfied?	Comments
RTU-1A	Classroom B1	Music/theater/dance	No	1,840	34	10	0.06	35	450	1	450	450	455	36%	164	(287)	-64%	No	VAV001E
RTU-1A	Classroom B1	Music/theater/dance	No	1,840	34	10	0.06	35	450	1	450	450	591	36%	213	(238)	-53%	No	VAV001W
RTU-1A	Classroom B2	Music/theater/dance	Yes	1,388	30	10	0.06	35	383	1	383	383	251	36%	90	(293)	-76%	Yes*	VAV002W
RTU-1A	Classroom B2	Music/theater/dance	Yes	1,388	30	10	0.06	35	383	1	383	383	422	36%	152	(231)	-60%	Yes*	VAV002E
RTU-1A	Classroom B4	Computer Lab	No	868	28	10	0.12	25	384	1	384	384	314	36%	113	(271)	-71%	No	VAV004
RTU-1A	Classroom B7	Computer Lab	No	352	6	10	0.12	25	102	1	102	102	230	36%	83	(19)	-19%	No	VAV007. Currently used as storage
RTU-1A	Classroom B9	Office spaces	No	269	2	5	0.06	5	26	1	26	26	102	36%	37	11	41%	Yes	VAV009
RTU-1A	Office 47	Office spaces	No	104	3	5	0.06	5	21	1	21	21	31	36%	11	(10)	-47%	No	VAV147. Shares Vav with storage closet.
RTU-1A	Classroom 51	Music/theater/dance	Yes	1,216	34	10	0.06	35	413	1	413	413	405	36%	146	(267)	-65%	Yes*	VAV151
RTU-1A	Classroom 54	Music/theater/dance	No	215	8	10	0.06	35	93	1	93	93	0	0%	-	(93)	-100%	No	VAV153
RTU-1A	Classroom 53	Classrooms (ages 5 to 8)	Yes	453	8	10	0.12	25	134	1	134	134	168	36%	60	(74)	-55%	Yes*	VAV153
RTU-1A	Classroom 50B	Classrooms (ages 5 to 8)	Yes	438	14	10	0.12	25	193	1	193	193	214	36%	77	(115)	-60%	Yes*	VAV150E
RTU-1A	Classroom50B	Classrooms (ages 5 to 8)	No	108	2	10	0.12	25	33	1	33	33	0	0%	-	(33)	-100%	No	VAV152
RTU-1A	Classroom 201	Office spaces	Yes	787.5	23	5	0.06	5	162	1	162	162	128	36%	46	(116)	-72%	Yes*	VAV201E
RTU-1A	Classroom 201	Classrooms (ages 9 plus)	Yes	788	23	10	0.12	35	325	1	325	325	152	36%	55	(270)	-83%	Yes*	VAV201W
RTU-1A	Classroom 202	Classrooms (ages 9 plus)	Yes	768	25	10	0.12	35	342	1	342	342	191	36%	69	(273)	-80%	Yes*	VAV202
RTU-1A	Classroom 203	Classrooms (ages 9 plus)	No	192	8	10	0.12	35	103	1	103	103	53	36%	19	(84)	-81%	No	VAV203
RTU-1A	Classroom 204	Classrooms (ages 9 plus)	Yes	768	25	10	0.12	35	342	1	342	342	337	36%	121	(221)	-65%	Yes*	VAV204
RTU-1A	Classroom 205	Classrooms (ages 9 plus)	No	380	14	10	0.12	35	186	1	186	186	187	36%	67	(118)	-64%	No	VAV205
RTU-1A	Classroom 208	Classrooms (ages 9 plus)	Yes	768	24	10	0.12	35	332	1	332	332	338	36%	122	(210)	-63%	Yes*	VAV208
RTU-1A	Classroom 209	Classrooms (ages 9 plus)	Yes	784	18	10	0.12	35	274	1	274	274	335	36%	121	(153)	-56%	Yes*	VAV209
RTU-1A	Classroom 50A	Classrooms (ages 9 plus)	Yes	736	22	10	0.12	35	308	1	308	308	488	36%	176	(133)	-43%	Yes*	VAV150W
RTU-1B	Classroom 57	Art Classroom	Yes	1,969	28	10	0.18	20	634	1	634	634	623	28%	174	(460)	-73%	Yes*	VAV157
RTU-1B	Conjoined Room between rm 57 and 67	Office spaces	No	108	4	5	0.06	5	26	1	26	26	153	28%	436	410	1547%	Yes	VAV165
RTU-1B	Classroom 67	Classrooms (ages 9 plus)	Yes	800	18	10	0.12	35	276	1	276	276	210	28%	474	198	72%	Yes	VAV167E
RTU-1B	Classroom 65	Classrooms (ages 9 plus)	No	168	5	10	0.12	35	70	1	70	70	153	28%	238	168	239%	Yes	VAV165
RTU-1B	Classroom 60	Classrooms (ages 5 to 8)	Yes	768	24	10	0.12	25	332	1	332	332	316	28%	88	(244)	-73%	Yes*	VAV160
RTU-1B	Classroom 62	Classrooms (ages 5 to 8)	Yes	768	22	10	0.12	25	312	1	312	312	309	28%	87	(226)	-72%	Yes*	VAV162
RTU-1B	Classroom 66	Classrooms (ages 5 to 8)	Yes	756	22	10	0.12	25	311	1	311	311	308	28%	86	(224)	-72%	Yes*	VAV166
RTU-1B	Classroom 68	Classrooms (ages 5 to 8)	Yes	768	16	10	0.12	25	252	1	252	252	311	28%	87	(165)	-65%	Yes*	VAVm168
RTU-1B	Classroom 213	Classrooms (ages 9 plus)	Yes	784	24	10	0.12	35	334	1	334	334	316	28%	88	(246)	-74%	Yes*	VAVm13
RTU-1B	Classroom 215	Classrooms (ages 9 plus)	Yes	784	20	10	0.12	35	294	1	294	294	388	28%	109	(185)	-63%	Yes*	VAVm215
RTU-1B	Classroom 216	Classrooms (ages 9 plus)	Yes	784	22	10	0.12	35	314	1	314	314	320	28%	90	(224)	-71%	Yes*	VAVm216
RTU-1B	Classroom 217	Classrooms (ages 9 plus)	Yes	756	23	10	0.12	35	321	1	321	321	271	28%	76	(245)	-76%	Yes*	VAVm217
RTU-1B	Classroom 218	Classrooms (ages 9 plus)	Yes	768	21	10	0.12	35	302	1	302	302	322	28%	90	(212)	-70%	Yes*	VAVm218
RTU-1B	Classroom 220	Classrooms (ages 9 plus)	Yes	768	22	10	0.12	35	312	1	312	312	324	28%	91	(221)	-71%	Yes*	VAVm220
RTU-1B	Classroom 221	Classrooms (ages 9 plus)	No	158	6	10	0.12	35	79	1	79	79	72	28%	20	(59)	-74%	No	VAVm221
RTU-1B	Faculty Dinning 225	Cafeteria/fast-food dining	No	396	10	7.5	0.18	100	146	1	146	146	316	28%	88	(58)	-40%	No	VAVm225
RTU-1B	Classroom 226	Classrooms (ages 9 plus)	Yes	784	20	10	0.12	35	294	1	294	294	316	28%	88	(206)	-70%	Yes*	VAVm226
RTU-2	Classroom 73	Classrooms (ages 9 plus)	Yes	845	21	10	0.12	35	311	1	311	311	358	27%	97	(215)	-69%	Yes*	VAVm173
RTU-2	Classroom 75	Classrooms (ages 9 plus)	Yes	778	23	10	0.12	35	323	1	323	323	410	27%	111	(213)	-66%	Yes*	VAVm175
RTU-2	Classroom 76	Classrooms (ages 5 to 8)	No	100	3	10	0.12	25	42	1	42	42	38	27%	10	(32)	-76%	No	VAVm174
RTU-2	Classroom 77	Classrooms (ages 5 to 8)	Yes	817	27	10	0.12	25	368	1	368	368	357	27%	96	(272)	-74%	Yes*	VAVm177
RTU-2	Classroom 78	Classrooms (ages 5 to 8)	Yes	923	16	10	0.12	25	271	1	271	271	327	27%	88	(182)	-67%	Yes*	VAVm178
RTU-2	Classroom 79	Classrooms (ages 5 to 8)	Yes	811	20	10	0.12	25	297	1	297	297	414	27%	112	(186)	-62%	Yes*	VAVm179
RTU-2	Classroom 227	Classrooms (ages 9 plus)	No	168	6	10	0.12	35	80	1	80	80	104	27%	28	(52)	-65%	No	VAVm227
RTU-2	Classroom 228	Classrooms (ages 9 plus)	No	319	16	10	0.12	35	198	1	198	198	129	27%	35	(163)	-82%	No	VAVm228
RTU-2	Office 228	Office spaces	No	80	1	5	0.06	5	10	1	10	10	0	0%	-	(10)	-100%	No	VAVm228
RTU-2	Workroom 231	Conference rooms	No	272	10	5	0.06	50	66	1	66	66	125	27%	34	(33)	-49%	No	VAVm231
RTU-2	Classroom 233	Conference rooms	Yes	518	12	5	0.06	50	91	1	91	91	210	27%	57	(34)	-38%	Yes*	VAVm233. Used as a teacher workroom.
RTU-2	Classroom 235	Classrooms (ages 9 plus)	Yes	759	28	10	0.12	35	371	1	371	371	284	27%	77	(294)	-79%	Yes*	VAVm235
RTU-2	Classroom 237	Classrooms (ages 9 plus)	Yes	817	21	10	0.12	35	308	1	308	308	663	27%	179	(129)	-42%	Yes*	VAVm237
RTU-2	Classroom 239	Classrooms (ages 9 plus)	Yes	817	21	10	0.12	35	308	1	308	308	338	27%	91	(217)	-70%	Yes*	VAVm239
RTU-2	Classroom 241	Classrooms (ages 9 plus)	Yes	799	24	10	0.12	35	336	1	336	336	491	27%	133	(203)	-61%	Yes*	VAVm241
RTU-2	Classroom 243	Classrooms (ages 9 plus)	Yes	863	23	10	0.12	35	334	1	334	334	1375	27%	371	38	11%	Yes	VAVm243
RTU-3	Classroom 45	Classrooms (ages 5 to 8)	No	161	6	10	0.12	25	79	1	79	79	254	10%	25	(54)	-68%	No	VAV145
RTU-3	Classroom 41	Office spaces	No	135	4	5	0.06	5	28	1	28	28	44	10%	4	(24)	-84%	No	VAV141
RTU-3	Office 38	Office spaces	Yes	68	1	5	0.06	5	9	1	9	9	104	10%	10	1	15%	Yes	VAV138
RTU-3	Nurse 39	Daycare Sickroom	No	575	10	10	0.18	25	204	1	204	204	70	10%	7	(197)	-97%	No	VAV139
RTU-3	Main Office 15	Main entry lobbies	No	475	4	5	0.06	10	49	1	49	49	150	10%	15	(34)	-69%	No	VAV115
RTU-3	Office 18	Office spaces	No	143	3	5	0.06	5	24	1	24	24	104	10%	10	(13)	-56%	No	VAV118
RTU-3	Office 21	Office spaces	Yes	130	5	5	0.06	5	33	1	33	33	95	10%	10	(23)	-71%	Yes*	VAV121
RTU-3	Workroom 22	Conference rooms	No	200	4	5	0.06	50	32	1	32	32	170	10%	17	(15)	-47%	No	VAV122
RTU-3	Office 23	Office spaces	Yes	195	6	5	0.06	5	42	1	42	42	89	10%	9	(33)	-79%	Yes*	VAV123
RTU-3	Office 25	Office spaces	Yes	344	10	5	0.06	5	71	1	71	71	174	10%	17	(53)	-75%	Yes*	VAV125
RTU-3	Nurse's office 32	Office spaces	Yes	182	2	5	0.06	5	21	1	21	21	140	10%	14	(7)	-33%	Yes*	VAV133
RTU-3	Office 30	Office spaces	Yes	95	2	5	0.06	5	16	1	16	16	102	10%	10	(6)	-35%	Yes*	VAV130
RTU-3	Exam room 31	Office spaces	Yes	60	1	5	0.06	5	9	1	9	9	102	10%	10	2	19%	Yes	VAV130
RTU-3	Office 33	Office spaces	Yes	95	4	5	0.06	5	26	1	26	26	140	10%	14	(12)	-46%	Yes*	VAV133
RTU-3	Office 26	Office spaces	Yes	143	5	5	0.06	5	34	1	34	34	146	10%	15	(19)	-56%	Yes*	VAV126
RTU-3	Conference rm 36	Conference rooms	Yes	242	10	5	0.06	50	65	1	65	65	129	10%	13	(52)	-80%	Yes*	VAV136
RTU-4	Gymnasium 6	Spectator areas	Yes	3,479	482	7.5	0.06	150	3,824	1	3,824	3,824	3989	19%	758	(3,066)	-80%	Yes*	
AHU-2	Dance Studio	Stages, studios	Yes	2,240	59	10	0.06	70	724	1	724	724	3833	37%	1,418	694	96%	Yes	4 VAVs serve this space. VAV101N
AHU-2	Custodian Office 2	Office spaces	No	131	3	5	0.06	5	23	1	23	23	78	37%	29	6	26%	Yes	VAV102
AHU-2	Computer Lab 5	Office spaces	Yes	253	4	5	0.06	5	35	1	35	35	176	37%	65	30	85%	Yes	VAV105
AHU-3	Lobby	Main entry lobbies	Yes	1,818	50	5	0.06	10	359	1	359	359	3040	37%	1,125				

Unit Tag	Room #	Category	ZoneArea, A2, per space (SF)	TAB Exhaust CFM	# of Toilets	# of Shower Heads	Calc'd Exhaust CFM	Ventilation Difference (CFM)	Code Satisfied?	Comments
	Boys BR Basement	Toilet rooms - private	136.5	259	3		75	184	Yes	
	Girls BR Basement	Toilet rooms - private	200.2	203	3		75	128	Yes	
	Classroom 50B BR	Toilet rooms - private	63.75	59	1		25	34	Yes	
	Boys BR across Room 50A	Toilet rooms - private	130	197	3		75	122	Yes	
	Girls BR across room 50A	Toilet rooms - private	201.5	234	3		75	159	Yes	
	Boys BR next to rm 209	Toilet rooms - private	100	118	3		75	43	Yes	
	Girls BR next to elevator	Toilet rooms - private	195	97	3		75	22	Yes	
	Faculty Dining 225 BR	Toilet rooms - private	105	23	1		25	(2)	No	
	Classroom 73 BR	Toilet rooms - private	52.5	36	1		25	11	Yes	
	Classroom 75 BR	Toilet rooms - private	52.5	52	1		25	27	Yes	
	Classroom 77 BR	Toilet rooms - private	56	22	1		25	(3)	No	
	Classroom 78 BR	Toilet rooms - private	42	0	1		25	(25)	No	
	Classroom 79 BR	Toilet rooms - private	56	30	1		25	5	Yes	
	Faculty BR	Toilet rooms - private	71.25	0	1		25	(25)	No	
	Girls BR across rm 237	Toilet rooms - private	195	38	3		75	(37)	No	
	Boys BR across rm 239	Toilet rooms - private	156	39	3		75	(36)	No	
	Girls BR next to rm 45	Toilet rooms - private	245	194	4		100	94	Yes	
	Boys BR across from gym	Toilet rooms - private	245	207	4		100	107	Yes	
	Unisex BR in nurse's office	Toilet rooms - private	96	97	1	1	25	72	Yes	
	Faculty BR across from gym	Toilet rooms - private	52.5	60	1		25	35	Yes	
	Faculty BR in rm 32	Toilet rooms - private	52	57	1		25	32	Yes	
	Faculty BR across rm 25	Toilet rooms - private	56	61	1		25	36	Yes	
	Boys BR next to Café	Toilet rooms - private	126	361	2		50	311	Yes	
	Girls BR next to Café	Toilet rooms - private	162	320	2		50	270	Yes	

Notes

No fresh air requirements for public bathrooms, only exhaust. Exhaust is 50 CFM or 70 CFM per water closet or urinal. If exhaust fan is intermittent than the higher value is used.

No fresh air requirements for private bathrooms, only exhaust. Exhaust is 25 CFM or 50 CFM per water closet or urinal. If exhaust fan is intermittent than the higher value is used.

No fresh air requirements for shower rooms, only exhaust. Exhaust is 20 CFM or 50 CFM per shower head. If exhaust fan is intermittent than the higher value is used.

Corridors are .06 CFM/sf only

Locker rooms are exhaust only at 0.5 CFM/sf

Corridors are .06 CFM/sf only



Appendix B: International Mechanical Code Minimum Ventilation Rates (2021) per ASHRAE 62.1

Minimum Ventilation Rates in Breathing Zone		People Outdoor Air Rate <i>R_p</i>	Area Outdoor Air Rate <i>R_a</i>	Default Values (Occupant Density)	Air Class	OS (6.2.6.1.4)	Comments
Occupancy Classification	Category	cfm/person	cfm/sf	#/1000sf			
Educational Facilities	Art Classroom	10	0.18	20	2	No	
Educational Facilities	Classrooms (ages 5 to 8)	10	0.12	25	1	No	
Educational Facilities	Classrooms (ages 9 plus)	10	0.12	35	1	No	
Educational Facilities	Computer Lab	10	0.12	25	1	No	
Educational Facilities	Daycare Sickroom	10	0.18	25	3	No	
Educational Facilities	Daycare (through age 4)	10	0.18	25	2	No	
Educational Facilities	Auditoriums	5	0.06	150	0		
Educational Facilities	Lecture Classroom	7.5	0.06	65	1	Yes	<i>Per ASHRAE, lecture classrooms are spaces with low space generated emissions and hard surfaces. Little off gassing so reduced levels. Most standard classrooms will be lecture classroom type.</i>
Educational Facilities	Lecture hall (fixed seats)	7.5	0.06	150	1	Yes	<i>University style (see occupant density)</i>
Educational Facilities	Libraries	5	0.12	10	n/a	No	
Educational Facilities	Media Center	10	0.12	25	1	No	
Educational Facilities	Multiuse assembly	7.5	0.06	100	1	Yes	
Educational Facilities	Music/theater/dance	10	0.06	35	1	Yes	
Educational Facilities	Science laboratories	10	0.18	25	2	No	
Educational Facilities	University/college laboratories	10	0.18	25	2	No	
Educational Facilities	Sports locker rooms	0	-0.7	0	0	No	
Educational Facilities	Wood/metal shop	10	0.18	20	2	No	
Food and Beverage	Bars, cocktail lounges	7.5	0.18	100	2	No	
Food and Beverage	Cafeteria/fast-food dining	7.5	0.18	100	2	No	
Food and Beverage	Kitchen (cooking)	7.5	0.18	20	2	No	
Food and Beverage	Restaurant dining rooms	7.5	0.18	70	2	No	
Private Dwellings	Toilet rooms - private	0	0	0	0		
Offices	Conference rooms	5	0.06	50	1	Yes	
Offices	Main entry lobbies	5	0.06	10	1	Yes	
Offices	Office spaces	5	0.06	5	1	Yes	
Offices	Reception areas	5	0.06	30	1	Yes	
Offices	Telephone/data entry	5	0.06	60	1	Yes	
Public spaces	Corridors	0	0.06	0			
Public spaces	Shower room	0	0	0			
Public spaces	Toilet rooms - public	0	0	0			
Public Assembly Spaces	Auditorium seating area	5	0.06	150	1	Yes	
Public Assembly Spaces	Libraries	5	0.12	10	1	No	
Public Assembly Spaces	Toilet rooms - public	0	0	0			
Sports and Entertainment	Bowling alley (seating)	10	0.12	40	1	No	
Sports and Entertainment	Disco/dance floors	20	0.06	100	2	Yes	
Sports and Entertainment	Gambling casinos	7.5	0.18	120	1	No	
Sports and Entertainment	Game arcades	7.5	0.18	20	1	No	
Sports and Entertainment	Gym, sports arena (play area)	20	0.18	7	2	No	
Sports and Entertainment	Health club/aerobics room	20	0.06	40	2	No	
Sports and Entertainment	Health club/weight room	20	0.06	10	2	No	
Sports and Entertainment	Spectator areas	7.5	0.06	150	1	Yes	
Sports and Entertainment	Stages, studios	10	0.06	70	1	Yes	
Sports and Entertainment	Swimming (pool and deck)	0	0.48	0	2	No	

Minimum Exhaust Rates				
Occupancy Classification	Category	CFM/fixture	CFM/SF	Comments
Educational Facilities	Toilet rooms - public	50	0	20
Educational Facilities	Toilet rooms - private	25	0	
Educational Facilities	Shower rooms	20	0	
Educational Facilities	Sports locker rooms	0	0.5	