Clara Barton Open School

Analysis of Building Ventilation Systems

Minneapolis Public Schools

COVID 19 Analysis of Building Ventilation Systems
Project Number: 20-472.00

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Title Page

Building Information

Building Owner:	Minneapolis Public Schools
Building Name:	Clara Barton Open School
Square Footage:	83,752 SF

4237 Colfax Avenue South
Minneapolis, MN 55409

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Table of Contents

Glossary of Terms and Abbreviations

ACH Air Change per Hour
- A measure of air flow in a specified volume of space

AHU Air Handling Unit
- HVAC equipment, typically contains fans, filters, and heating and/or cooling coils

AII room Airborne Infection Isolation room
- Room with mechanical systems designed to reduce the spread of airborne infection disease to other areas

ASHRAE American Society of Heating, Refrigerating, and Air-conditioning Engineers
- Professional organization that supports industry research and publishes design best practice guidelines and standards

BAS Building Automation System
- Control system for building HVAC and lighting systems

CAV Constant Air Volume
- Describes the type of control of an AHU- this type of unit varies the supply air temperature but not the volume of air flow

CFM Cubic Feet per Minute
- Measure of volumetric flow, typically used for air flow

DOAS Dedicated Outdoor Air System
- AHU that supplies 100% conditioned outdoor air (does not mix ventilation air with recirculated room air)

ERU Energy Recovery Unit
- AHU with a heat exchanger to transfer heat between exhaust air and incoming outdoor air

HEPA High Efficiency Particulate Air (filter)
- A type of filter that can remove at least 99.97% of particles with a size of 0.3 microns.

HVAC Heating, Ventilation, and Air-conditioning
- Term used to describe building systems and technical expertise of professionals

MERV Minimum Efficiency Reporting Value
- A filter's ability to capture particles between 0.3 and 10 microns in size
- A higher MERV rating captures a larger percentage of small particles
- See Appendix D for MERV ratings and ratings by particle size

OA Outdoor Airflow
- Ventilation air flow

SF Square Feet
- Measure of area

TAB Test and Balance
- Measurement and adjustment of building HVAC equipment.

VAV Variable Air Volume

- Describes the type of control of an AHU- this type of unit varies both the supply air temperature and the volume of air flow to a zone
- Also used to describe the piece of equipment in a zone that includes a damper to reduce airflow (VAV box)

VRF Variable Refrigerant Flow

- A type of refrigeration system that includes an outdoor condensing unit and indoor fan units with a cooling coil. Sometimes the indoor unit also includes a heating coil.

Executive Summary

Minneapolis Public Schools (MPS) requested individual facility ventilation studies for all occupied elementary, middle school, and high school buildings. These studies identified improvements to the air handling units (AHUs) and ventilation in the buildings that will allow the building to meet current ASHRAE guidance to limit virus transmission in the ventilation system in the building.

Adequate outdoor air flow, or ventilation, can dilute the number of viral particles in the breathing zone of a space. Effective filtration can remove particles from the air. However, viral particles are extremely small. Most filters are not rated to capture particles as small as the virus that causes COVID-19, but some can capture a large fraction of viral-sized particles. While it will not be practical to rely only on filtration, increasing filtration levels will reduce the number of viral particles in the air.

This report provides the results for Clara Barton Open School. KFI has reviewed existing HVAC plans, Test-and-Balance (TAB) reports, and the building automation system (BAS). KFI has also performed an onsite evaluation for the facility.

Clara Barton Open School has four air handling units that supply different spaces. The filtration levels of each HVAC system are detailed in the Building Assessment section, and the final filter MERV levels are provided in Table 1, Table 2, and Table 3. The following is a description of these areas:

1. There are three systems that were installed in 1997: AHU-1, AHU-2, and AHU-3. These units serve Multi-purpose area, office area, gymnasium and classrooms.
2. AHU-4 was replaced in 2001 and serves classrooms.
3. This building is heated by hot water and cooled by a chilled water plant.

111a Workroom has been identified as a potential isolation area for students or staff who fall ill during the day. This room would require the addition of an exhaust system and would require ill persons to cross a small corridor between the nurse's office and workroom.

Through this project, a number of conditions were identified that could be corrected immediately. Table 1 summarizes these immediate corrections. Table 2 summarizes recommendations for future system updates that do not require significant capital improvements. Table 3 identifies recommended improvements that will require a capital program expenditure to complete. These improvements should be part of a larger capital effort for improvement to ventilation systems Districtwide.

Table 1: Summary of Immediate Corrections

System Tag	Existing Filtration Level*	Serves	Work in Progress
AHU-01	MERV12	Multi-Purpose	• Replace pre filters with like-for-like • Change schedules to start at 4am
AHU-02	MERV8	Gymnasium	• Replace pre filters with like-for-like • Change schedules to start at 4am • Disable demand control ventilation.
AHU-03	MERV12	North Classrooms	• Replace final filters with **MERV14** • Replace pre filters with like-for-like • Change schedules to start at 4am
AHU-04	MERV11	South Classrooms	• Replace final filters with **MERV14** • Replace pre filters with like-for-like • Change schedules to start at 4am • Adjust final filter rack to secure filters in place

Table 2: Summary of Recommendations without Significant Capital Expenditures

System Tag	Existing Filtration Level*	Serves	Recommendations
AHU-01	MERV12	Multipurpose	• Rebalance unit to increase ventilation flow to 4,400 cfm
AHU-02	MERV8	Gym	• Measure OA to confirm ventilation rate. Rebalance if unit is below code minimum value of 863.

Table 3: Summary of Recommendations Requiring Capital Expenditures

System Tag	Existing Filtration Level*	Serves	Recommendations
AHU-1	MERV12	Multi-purpose	• Convert 111a Workroom in the school to an isolation area • Consider adding a standalone HEPA filter to the nurse's office • Replace entire AHU to accommodate code required outdoor air and increased filtration of **MERV14**.
AHU-2	MERV8	Gym	• Install filter rack for final filters. • Add **MERV 14** final filters.

Disclaimer

Performance guidelines provided in the report are for informational purposes only and are not to be construed as a design document. Recommendations implemented should be installed in conformance to all local code requirements.

Ventilation and filtration recommendations are provided based on ventilation requirements in the Minnesota 2020 Mechanical Code and guidance from ASHRAE on limiting viral transfer. If equipment was installed under an earlier code that equipment is not required to comply with the 2020 code.

Introduction

Clara Barton Open School is a three story facility, operating as a public K-8 magnet school. Renovations occurred in 1997 which replaced three of the building air handling units (AHU-1, 2 and 3), and in 2000 replacing AHU-4. The building is 83,752 sf. Constant volume and variable-air-volume (VAV) systems provide heating, cooling, and ventilation to all areas in the building.

Students have not occupied the school building since March of 2020 due to the COVID-19 pandemic.

The SARS-CoV-2 virus causes coronavirus disease, or COVID-19. The SARS-CoV-2 virus is new and research into the virus and disease spread is still evolving. So far, we have learned that primary transmission route of the virus is via the air in droplets and aerosols. Recommendations for reducing the spread of COVID-19 focus broadly on: 1) maintaining social distance between people, 2) sanitizing and cleaning surfaces, and 3) reducing the number and circulation of viral particles in the air. HVAC systems can influence this last item.

Adequate outdoor airflow, or ventilation, can dilute the number of viral particles in the breathing zone of a space. Effective filtration can remove particles from the air. However, viral particles are extremely small, on the order of 0.12 microns. Filters are typically rated by the size of particles that will be removed, for example, MERV 14 filters are rated to remove 95% or greater of particles down to 3 microns. While it will not be practical to rely only on filtration, increasing filtration levels will reduce the number of viral particles in the air.

ASHRAE guidance is available online at:
https://www.ashrae.org/technical-resources/reopening-of-schools-and-universities.

This report provides the results for Clara Barton Open School. KFI has performed the following scope of work:

- Reviewed the existing HVAC building plans and test and balance reports (TAB) to identify recommended improvements to the systems to meet current ASHRAE guidance for COVID19.
- Performed an on-site assessment of the facility.
- Reviewed the building automation system (BAS) to determine potential control changes to improve indoor air quality

ASHRAE Guidance

The American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) provides research, standards, and continuing education that typically define best practice in the HVAC industry. ASHRAE has been developing industry standards for best practice in reducing HVAC spread of airborne illnesses for years.

ASHRAE has released guidance for schools and universities to prepare for the reopening of school buildings. This advice focuses on three core principles aimed at reducing the spread of COVID19:

1. Increase outdoor air where possible
    a. Follow current ventilation standards at a minimum
    b. Ventilate at least 2 hours prior to occupancy
    c. Disable demand controlled ventilation during the pandemic
2. Increase filtration levels where possible
    a. MERV15 filtration provides similar filtration levels as an N95 mask (95% of particles entrapped to 3 microns in size)
    b. MERV14 filtration is recommended where possible
3. Maintain indoor environments between 40% and 60% relative humidity and temperatures between 68°F and 78°F where possible

This project focuses on the first two principles above. It seeks to evaluate the ventilation and filtration levels in the existing systems, to evaluate system capacity to increase outdoor air and filtration levels, and to evaluate building control systems to recommend changes.

Temperature maintenance for buildings is provided in Board Regulation 3520A. Due to the complexity of establishing and maintaining relative humidity in a space, MPS is not evaluating the relative humidity as part of this study.

Building Assessment / Recommendations

HVAC System Filtration and Ventilation

Constant volume and variable-air-volume (VAV) systems provide heating, cooling, and ventilation to the building. A summary of the systems in the building is provided in Table 4. A matrix was developed for the school systems with airflows, static pressures, filtration, and control details. This matrix is provided in Appendix A.

Table 4: System Overview

System Tag	Age	Serves	System Type
AHU-01	1997	Multi-purpose	VAV
AHU-02	1997	Gym	Constant
AHU-03	1997	North classrooms	VAV
AHU-04	2001	South Classrooms	VAV

AHU-1

AHU-1 serves Multi-purpose area and office spaces, it was installed in 1997. AHU-1 does not bring in enough outdoor air to meet the current design ventilation rates. By default the ASHRAE people count for the total area served by this unit is 527. However we recommend increasing the outdoor air flow of this unit to meet the current code levels. Review of the design heating coil sizes suggests that this unit can support the increase in outdoor air flow to achieve the original design OA. To obtain current code ventilation rates, we recommend replacement of the heating coil.

This unit has MERV 8 pleated pre filters and MERV 12 bag type after filters. MERV 14 filtration is recommended where possible per ASHRAE. With no additional static pressure (SP) between the design total static pressure and the actual total static pressure, we recommend the replacement of the supply fan to accommodate the additional pressure loss from the new MERV 14 after filters.

Ventilation air flows and static pressures are summarized in Table 5.

Table 5: System Ventilation and Static Pressure – AHU-1

System	Area Served [sf]	Actual OA [cfm]	Design OA [cfm]	Code OA [cfm]	Design Total SP [in wc]	Actual Total SP [in wc]
AHU-1	12,409	3,625	4,400	6,465	3.0	3.36

AHU-2

AHU-2 serves the gymnasium, it was installed in 1997. The actual OA cfm was not listed in the TAB report. While the design OA cfm meets current code requirements, we recommend measuring the actual OA to verify that it meets the code OA cfm.

This unit has MERV 8 pleated pre filters and no final filters installed. This unit can support MERV 14 final filters. We recommend that the final filters be added at MERV 14 rating. This will require installation of a final filter rack.

Ventilation air flows and static pressures are summarized in Table 6.

Table 6: System Ventilation and Static Pressure – AHU-2

System	Area Served [sf]	Actual OA [cfm]	Design OA [cfm]	Code OA [cfm]	Design Total SP [in wc]	Actual Total SP [in wc]
AHU-02	2,158	NA	1,000	863	3.5	2.7

AHU-3

AHU-3 serves the northern classrooms, on all three levels, and was installed in 1997. AHU-03 does bring in enough outdoor air to meet the current design ventilation rates

This unit has MERV 8 pleated pre filters and MERV 11 after filters. This unit can support MERV 14 final filters. We recommend that the final filters be changed to MERV 14 rating. Figure 1 illustrates current filter bank within AHU-3.

Table 7: System Ventilation and Static Pressure – AHU-3

System	Area Served [sf]	Actual OA [cfm]	Design OA [cfm]	Code OA [cfm]	Design Total SP [in wc]	Actual Total SP [in wc]
AHU-3	4,754	2,660	4,000	2,535	3.0	2.47

Figure 1: AHU-3 Pre and After Filters

AHU-4

AHU-4 serves southern classrooms on all three levels, it was installed in 2001. AHU-4 does supply enough OA to meet current codes.

This unit has 2" MERV 8 pleated pre filters and 4" MERV 11 box type after filters. This unit can support MERV 14 final filters. We recommend that the final filters be changed to MERV 14 rating. Refer to Figure 2, it was noted the final filter rack needs repairs to ensure filters stay in place.

Table 8: System Ventilation and Static Pressure – AHU-4

System	Area Served [sf]	Actual OA [cfm]	Design OA [cfm]	Code OA [cfm]	Design Total SP [in wc]	Actual Total SP [in wc]
AHU-4	17,917	23,399	10,000	6,575	6.6	5.74

Figure 2: AHU-4 after filter blown out

Intake and Exhaust Separation

All intakes and exhaust vents are separated by more than the recommended 10 feet of distance.

Building Automation System

At the time of reporting, access to Clara Barton Open School was not accessible. Recommendations below are consistent typical units throughout the District.

Before the building is occupied we recommend changing the system operation schedules to have the AHU fans start 2 hours before occupancy.

AHU-2 may have demand control with CO2 setpoints. We recommend disabling demand control ventilation and introduce max OA.

Maximizing the economizer mode would help with ventilation when outside temperatures are 71°F or below. We recommend disabling the economizer sequence once outside air temperatures reach 71°F. In addition to increasing the enable temperature for economizer modes, we recommend implementing max VAV damper positions for all VAVs during economizer mode to maximize the ventilation airflow to the VAVs.

Nurse and Office Area Air Flow

Summaries of the airflows in the nurse and main office are provided in the tables below. The outdoor air flow for AHU-1 that serves these areas is 16% of the maximum supply flow. It is recommended to rebalance to the minimum OA cfm from the design documents to meet the code OA. Air from the nurse's office is mixed with the general AHU-1 return air so it would need a separate system to serve as an isolation area. A stand-alone HEPA filtration unit at a capacity of 12ACH located in the nurse's office would limit the viral particles that are returned to the RTU.

Table 9: Nurse's Office Air Flow

Health area HVAC System	Supply Air Flow to Health Room (cfm)	Area of Health Room (sf)	Ceiling Height of Health Room (ft)	Current ACH	Percent OA
AHU-1	150	78	9	15.3	16%

Table 10: Main Office Air Flow

Office area HVAC System	Supply Air Flow (cfm)	Area of Main Office (sf)	Ceiling Height (ft)	Current ACH	Percent OA
AHU-1	1350	220	9	40	16%

Potential Isolation Areas

Areas have been identified that could be renovated to serve as an isolation room for students who fall ill during the day. This area would need to be designed around ASHRAE Standard 170-2017 Ventilation of Health Care Facilities for Airborne Infection Isolation (AII) Rooms. The AII room would need to be maintained with a negative pressure relationship to adjoining rooms with a minimum of 2 ACH of outdoor air and a minimum 12 ACH of total supply air. All room air will need to be exhausted. If the 12 ACH of supply air is not possible, a HEPA filtered recirculating unit could be provided to increase equivalent ACH requirements. When the room is not used for AII conditions, the room would need to remain with a negative pressure relationship and the minimum supply air rate could be reduced to 6 ACH.

The potential isolation area identified: Workroom 111a.

Table 11: Airflow of Potential Isolation Areas

Room or Area	HVAC System	Supply Air Flow (cfm)	Floor Area (sf)	Ceiling Height (ft)	Current Total ACH	Current ACH of OA	Required ACH	Required ACH of OA
111a Workroom	RTU-05	400	80	9	30.0	5.3	12	2

111a Workroom is served by AHU-1 along with the office and nurse areas. Its location is highlighted in red in Figure 3. If this area were to be converted to an isolation room it would need to have the room walls sealed, a new dedicated exhaust system at approximately 15 ACH (180 CFM), cap current return air back to AHU-1, and continued use of existing supply from VAV-2.5. A new exhaust fan and room pressure controller will need to be added to maintain the required pressure relationship. The anticipated capital construction costs would be between $75,000 to $90,000.

Access to the 111a Workroom is across the corridor from the Nurses office.

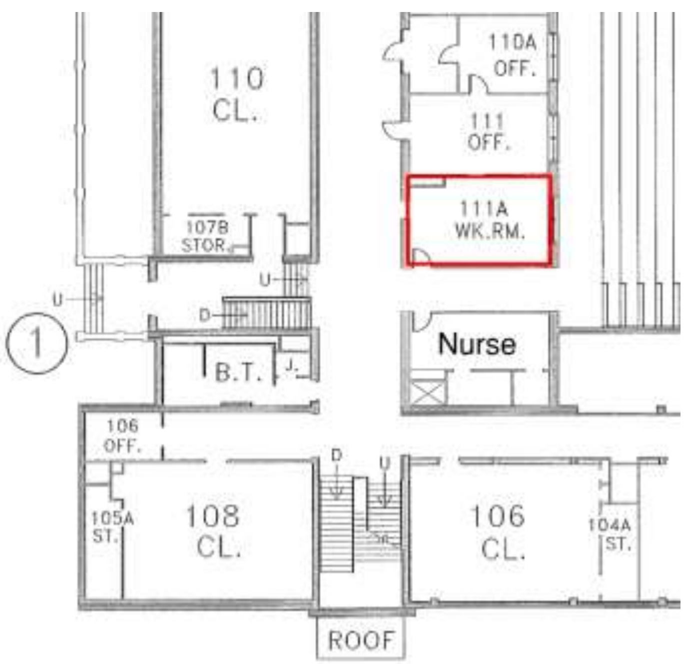

Figure 3: Isolation Room

Appendices

Appendix A – Matrix of Existing HVAC Systems

KFI ENGINEERS

MPS Equipment Schedule

TAG	Make and Model #	Serial #	Age	Area Serving	Area Square Footage	Test & Balance Date	Air Distribution System Type DOAS, VAV, CONSTANT, etc	Comments related to air distribution SA/RA close, furniture blocking airflow, etc.	Supply Fan Motor Nameplate HP	Actual Supply Air Flow CFM	Design Supply Air Flow CFM
AH-01	Trane MCCA050MAG0C0B0AD00000000	K97M43582A	1997	MULTI-PURPOSE	12,409	10/17/2019	VAV	No Issues	30.0	NA	22,000.0
AH-02	Trane MCCA014GAR0ACA000G0CEA00D0BC000AC000C000000A0	K97L33873A	1997	GYMNASIUM	2,158	10/7/2019	CONSTANT	No Issues	10.0	NA	6,000.0
AH-03	Trane MCCA025GAR0ACC000H0CEA00D0BC000AC000D000000A	K97L33892A	1997	NORTH CLASSROOMS	4,754	10/7/2019	VAV	No Issues	15.0	8,498.0	9,500.0
AHU-04	McQuay CAH050FDDC	BOU010400651	2001	SOUTH CLASSROOMS	17,917	10/16/2019	VAV	No Issues	50.0	NA	29,000.0

KFI ENGINEERS

MPS Equipment Schedule

TAG	Actual OA CFM	Design OA CFM	Code OA CFM	Design Total SP in.wc.	Actual Total SP in.wc.	Existing Filter type ex: 2" pleated MERV 8	Filter dimensions and count ex: 2@20"x30"	Comments Related to Filter and Filter Rack Condition
AH-01	3,625	4,400	6,465	3.0	3.36	2" PLEATED PRIMARY 15" BAG FINAL	Prefilters: 4 at 24"x20"x2", 1 at 20"x20"x2", Final filters top and bottom: 8 pleated at 24"x24"2", 1 at 20"x24"x2" Final center: 4 at 24"x20"x15" 6 pocket, 1 at 20"x20"x15" 5 pocket	No issue
AH-02	NR	1,000	863	3.5	2.7	2" PLEATED PRIMARY 15" BAG FINAL	Prefilters: 2 at 24"x20"x2", 1 at 24"x24"x2"	No final filter installed.
AH-03	2,660	4,000	2,535	3.0	2.47	2" PLEATED PRIMARY 15" BAG FINAL	Prefilters: 6 at 24"x24"x2", Final: 6 at 24"x24"x15" 6 pocket	No issue
AHU-04	23,399	10,000	6,575	6.6	5.74	2" PLEATED PRIMARY 4" BOX FINAL	Prefilters: 12 at 24"x24"x2", 3 at 20"x24"x2", Final: box 12 at 24"x24"x4", 3 at 20"x24"x4"	Adjust final filter rack to ensure 4" filters do not blow out

Appendix B – Building System Maps

Redacted for Security Reasons

Figure 4: Ground Floor Systems Map

Figure 5: First Floor Systems Map

Figure 6 Second Floor Systems Map

Appendix C – Building Equipment Location Maps

Created by MPS staff

Redacted for Security Reasons

Appendix D – MERV Filter Ratings

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			Average Arrestance, %
	Range 1 (0.3-1.0)	Range 2 (1.0-3.0)	Range 3 (3.0-10.0)	
1	n/a	n/a	$E3 < 20$	$A_{avg} < 65$
2	n/a	n/a	$E3 < 20$	$65 \le A_{avg} < 70$
3	n/a	n/a	$E3 < 20$	$70 \le A_{avg} < 75$
4	n/a	n/a	$E3 < 20$	$75 \le A_{avg}$
5	n/a	n/a	$20 \le E3$	n/a
6	n/a	n/a	$35 \le E3$	n/a
7	n/a	n/a	$50 \le E3$	n/a
8	n/a	$20 \le E_2$	$70 \le E3$	n/a
9	n/a	$35 \le E_2$	$75 \le E3$	n/a
10	n/a	$50 \le E_2$	$80 \le E3$	n/a
11	$20 \le E_1$	$65 \le E_2$	$85 \le E3$	n/a
12	$35 \le E_1$	$80 \le E_2$	$90 \le E3$	n/a
13	$50 \le E_1$	$85 \le E_2$	$90 \le E3$	n/a
14	$75 \le E_1$	$90 \le E_2$	$95 \le E3$	n/a
15	$85 \le E_1$	$90 \le E_2$	$95 \le E3$	n/a
16	$95 \le E_1$	$95 \le E_2$	$95 \le E3$	n/a

https://www.nafahq.org/understanding-merv-nafa-users-guide-to-ansi-ashrae-52-2/