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Thesis Technical Assignment I

Manoa Elementary School

[ASHRAE 62.1 & 90.1 COMPLIANCE REPORT]

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Executive Summary

Manoa Elementary School is a recently constructed, multi-level, 85,000 square foot elementary school located in the Philadelphia suburbs. The building includes classrooms for grades K-5, faculty office space, music and art rooms, a multi-purpose gymnasium space, and a cafeteria/kitchen. The building was designed to maximize the amount of playing field space available to the community.

ASHRAE Standard 62.1 is a prescribed method for analyzing the effects of equipment on the indoor air quality of the building and contains a prescriptive method to calculate the minimum outdoor air flow required for the occupancy type and density for a space. All systems were used for the calculation of required outdoor air intake. Compliance to this standard is briefly described in the tables below:

ASHRAE Standard 62.1 Section 5 Compliance	
5.1 Natural Ventilation	Yes
5.2 Ventilation Air Distribution	Yes
5.3 Exhaust Duct Location	N/A
5.4 Ventilation System Controls	Yes
5.5 Airstream Surfaces	Yes
5.6 Outdoor Air Intakes	Yes
5.7 Local Capture of Contaminants	Yes
5.8 Combustion Air	Yes
5.9 Particulate Matter Removal	Yes
5.10 Dehumidification Systems	Yes
5.11 Drain Pans	Yes
5.12 Finned-Tube Coils and Heat Exchangers	Yes
5.13 Humidifiers and Water-Spray Systems	N/A
5.14 Access for Inspection, Cleaning and Mai	Yes
5.15 Building Envelope and Interior Surfaces	Yes
5.16 Buildings with Attached Parking Garage	N/A
5.17 Air Classification and Recirculation	Yes
5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas	N/A

Compliance Summary				
	Calculated Outdoor Air	Design Supply Air Flow	Design Minimum Outdoor Air	ASHRAE 62.1 Compliance
AHU-1	**8051 cfm**	**20395 cfm**	**7000 cfm**	**No**
AHU-2	7250 cfm	20750 cfm	8000 cfm	Yes
AHU-3	2565 cfm	13600 cfm	5300 cfm	Yes
AHU-4	**5192 cfm**	**5800 cfm**	**3000 cfm**	**No**
AHU-5	3579 cfm	8090 cfm	4500 cfm	Yes

ASHRAE Standard 90.1 is the prescriptive method for analyzing the energy efficiency of a building. This standard focuses on defining energy efficient measures to be applied to the building envelope, heating, ventilating and air conditioning systems, service hot water heating systems, power and lighting of a building. Manoa Elementary School did not meet all the prescriptive requirements of this section. A summary of compliance is included below.

Insulation Requirements		
	Required	Compliance
Wall R- Value	9.5	Yes
Roof R-Value	**20**	**No**
Fenestration U-Value	0.55	Yes
Fenestration Max SHGF	0.4	Yes

Window Area Summary		
	% Glazing	Compliance
Walls	16%	Yes
Roof	0%	Yes

Air Conditioners, air-cooled		
Symbol	Required EER	Compliance
AHU-1	9.2	Yes
AHU-2	9.2	Yes
AHU-3	**9.3**	**No**
AHU-4	**9.3**	**No**
AHU-5	**9.3**	**No**

Pipe Insulation			
	Nominal Pipe Diameter	Required Insulation Thickness	Compliance
Heating Systems 141-200˚ Operating Temp	<1"	1	Yes
	1 to 1-1/2"	1	Yes
Domestic and Hot Water Service Systems	<1"	0.5	Yes
	1 to 1-1/2"	0.5	Yes
	1-1/2" to 4"	1	Yes
Cooling Systems 40-60˚ Operating Temp	<1"	0.5	Yes
	1 to 1-1/2"	0.5	Yes

Lighting Power Density Analysis		
	Maximum from Standard	Compliance
First Floor	1.2	Yes
Second Floor	1.2	Yes
Third Floor	1.2	Yes
Total	**1.2**	**Yes**

ASHRAE 62.1 Section 5 Compliance Report

ASHRAE Standard 62.1is used to specify measures that will improve the indoor air quality in a building that is both acceptable for the human occupants and will minimize health effects. Section 5 details these measures for systems and equipment.

5.1 Natural Ventilation

Double hung operable windows hung in the classrooms can be used as a means of natural ventilation in conjunction with mechanical ventilation. From the table in Appendix A, it can be seen that most spaces comply with the size requirement. All windows are manufactured and installed to allow easy operation from occupants.

5.2 Ventilation Air Distribution

Variable Air Volume boxes are used to control the ventilation airflow to each space as required by Section 6 of this standard. An analysis of the compliance with this section is included in this report.

5.3 Exhaust Duct Location

All kitchen air exhaust ducts are sealed following the requirements of SMACNA Seal Class A, therefore this section does not apply.

5.4 Ventilation System Controls

Run conditions of the air handling units are based upon an operator adjustable schedule in one of the following modes: summer occupied, summer unoccupied, school year occupied, school year unoccupied, and stand-by. In addition to running when scheduled, the units are enabled to run when any of its respective fan powered boxes call for cooling or its respective VAV shutoff boxes calls for heating or cooling. When the air handling units are in occupied mode and the supply fan status is confirmed on, the minimum outside air damper shall open and the respective energy recovery ventilator shall be enabled. The control method described above complies with the requirements of this section.

5.5 Airstream Surfaces

Project specifications call for the use of a duct liner which complies with NFPA 90A and NAIMA's "Fibrous Glass Duct Liner Standard." The liner is constructed to prevent erosion of glass fibers and coated to meet the requirements of NFPA 90A and impregnated with an EPA-Registered biocide to inhibit mold and bacteria growth is installed in transfer air ducts and other ducts specifically noted on drawings. This specification complies with the requirements of the standard.

5.6 Outdoor Air Intakes

The location of exhaust fans relative to outdoor air intakes was analyzed using Table 5.1. Results are as follows:

Air Intake Minimum Separation Distance			
EF-1	Kitchen Grease Hood	Contaminated	12.75 ft
EF-3	Dishwasher Hood	Contaminated	23.33 ft
EF-4	Boiler Room	Contaminated	51.25 ft
EF-5	Kiln Hood	Contaminated	33.25 ft
EF-14	Refrig. Leak Emerg. Exh	Noxious/Dangerous	25 ft
EF-15	Mechanical Room	Contaminated	N/A ft

Most fans were determined to be irrelevant to the analysis. Shown above are the exhaust fans categorized in notes 1 and 3 of this table. Above fans categorized as "contaminated" were done so because it is reasonable to believe the exhaust may contain harmful contaminants if not solely an offensive odor. All fans categorized as such meet the minimum requires separation distance of 15 feet except for the kitchen grease hood which is located too close to the make-up air intake for the kitchen. Exhaust fan 14 is the refrigerant leak emergency exhaust fan which under Note 3 categorizes the air as noxious requiring a 30 foot separation which is not met.

The base of all rooftop air handling units shall overhang the roof curb for water runoff and have a formed recess that seats on the roof curb gasket to provide a positive weather tight seal. Access doors and bird screens are included to prevent snow infiltration and nesting.

5.7 Local Capture of Contaminants

All potentially harmful exhaust is ducted to the roof and exhausted from here, meeting the requirements of the section.

5.8 Combustion Air

Both boilers are equipped with a set of dampers controlled to provide adequate air for combustion. Exhaust is ducted to the roof and exhausted with aid of exhaust fans. Emergency generator located in the mechanical has a ducted exhaust out of the side of the building. These measures comply with the requirements of the section.

5.9 Particulate Matter Removal

All air handling units are equipped with two sets of replaceable type MERV 8 prefilters and two sets of cartridge type MERV 13 final filters. During construction only one set of filters is to be installed until after the final clean up of the area after which the second set will be installed. Both filters exceed the minimum requirement of this section of MERV 6.

5.10 Dehumidification Systems

No separate dehumidification system is used beyond the capability of the air handling units to dehumidify the air as it is heated. Interior spaces are designed with a relative humidity below 65% except for the kitchen, which is okay under this section.

This section also specifies that the design minimum outdoor air intake is to be greater than the design maximum exhaust airflow when the mechanical air conditioning systems are dehumidifying. Analyses of the buildings exhaust fans and air handling units can be seen in the table below. As shown in the table, the minimum outdoor air intake is in fact greater than the maximum airflow exhausted therefore the system meets the requirements of this section.

Exfiltration Analysis

Exhaust			
Symbol	Serves	System CFM	
EF-1	Kitchen Grease Hood	4,850	cfm
EF-2			cfm
EF-3	Dishwasher Hood	1,350	cfm
EF-4	Boiler Room	3,200	cfm
EF-5	Kiln Hood	500	cfm
EF-6	General Exhaust (AHU-1)	1,325	cfm
EF-7	General Exhaust (AHU-2)	1,925	cfm
EF-8	General Exhaust (AHU-5)	1,630	cfm
EF-9	General Exhaust (AHU-5)	735	cfm
EF-10	General Exhaust (AHU-3)	1,680	cfm
EF-11	General Exhaust (AHU-3)	275	cfm
EF-12	General Exhaust (AHU-4)	150	cfm
EF-13	General Exhaust (AHU-2)	870	cfm
EF-14	Refrig. Leak Emer. Exh.	200	cfm
EF-15	Mechanical Room	800	cfm
SF-1	Electrical Room	7,000	cfm
		26,490	cfm

Outdoor Air Intake		
Symbol	OA CFM	
AHU-1	7,000	cfm
AHU-2	8,000	cfm
AHU-3	5,300	cfm
AHU-4	3,000	cfm
AHU-5	4,500	cfm
	27,800	cfm

5.11 Drain Pans

Specifications call for a double-sloped, insulated, stainless steel drain pan is to be provided with the cooling coil and will extend beyond the leaving side of the coil and under the cooling coil connections. The drain pan is to be connected to a threaded drain connection that extends through the unit housing. Drain pan piping is to be constructed to Schedule 40 PVC pipe with a deep seal p-trap and assembled with Type DWV solvent welded fittings. Piping is terminated over a 4-inch solid concrete splash block on the roof. These specifications meet the sections requirements.

5.12 Finned-Tube Coils and Heat Exchangers

All finned-tube heat exchangers are used for heating only so no drain pan is required. Service height for this unit is 19.5" which exceeds the required 18" of this standard.

5.13 Humidifiers and Water-Spray Systems

There is no steam or direct evaporation humidifiers, air washers or other water spray systems used in this project so this section does not apply.

5.14 Access for Inspection, Cleaning, and Maintenance

All ventilation equipment is installed with adequate space to facilitate routine maintenance and inspection. All air handling units and fan powered boxes are equipped with access doors or panels for easy access, meeting the requirements of the standard.

5.15 Building Envelope and Interior Surfaces

A vapor barrier coupled with an airspace behind the brick finish provides an adequate means of preventing condensation from forming on cold surfaces of the building envelope.

Supply and return air ducts to all air handlers and energy recovery ventilators are insulated in compliance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" Second Edition, 1995 to prevent condensation. Pipes expected to produce condensation are to be insulated with Mineral-Fiber Insulation, Flexible Elastomeric Thermal Insulation, Calcium Silicate Insulation or Prefabricated Thermal Insulating Fitting Covers complying with ASTM standards, as per the specifications and meeting the requirements of the section.

5.16 Buildings with Attached Parking Garages

Manoa Elementary School does not have an attached parking garage so this section does not apply.

5.17 Air Classification and Recirculation

Most of the building air can be classified as Class 1 and recirculated. Kitchen exhaust fall into Classes 3 & 4 and is directly exhausted with no recirculation. Any Class 2 air can be re-designated as Class 1 air by circulating through the energy recovery ventilator. These classifications meet the requirements of the section.

5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas

Manoa Elementary School is a smoke-free facility therefore this section does not apply.

ASHRAE 62.1 Section 6 Compliance Report

ASHRAE Standard 62.1 Section 6 is a prescriptive procedure to calculate the minimum outdoor air intakes required based on contaminant sources and source strengths typical for the particular space type. This calculation requires an analysis of the spaces served, occupancy level and square footage.

Systems Analyzed

Although it was not necessary to analyze all systems because two separate systems serve the classroom areas, all were analyzed for completeness.

AHU's 1&2 are dedicated to conditioning the classroom areas of all three floors in Unit A. AHU-3 is responsible for serving the office and classroom portion of Unit B. AHU-4's sole purpose is to condition the multipurpose "gymnasium" area. Lastly, AHU-5 serves the kitchen and cafeteria portion of Unit B.

Calculation Variables and Assumptions

- A_z is defined as the zone floor area. For calculation purposes this area was taken from architectural floor plans.
- P_z is defined as the zone population. This population is the maximum number of people expected to occupy the zone during typical occupancy. This number was selected based on Table 6-1 "Minimum Ventilation Rates in Breathing Zone" unless a specific occupancy was determined by the architect. It was assumed for classroom analysis that Classrooms (ages 5-8) applied to classrooms for grades K-3 and Classrooms (age 9+) applied to fourth and fifth grade classrooms.

- **R_p** is defined as the outdoor airflow rate required per person. This number is based on the occupancy category of the zone and is found in Table 6-1.
- **R_a** is defined as the outdoor airflow rate required per square foot. This number, like R_p, is based on occupancy category and found in Table 6-1.
- **E_z** is defined as the zone air distribution effectiveness. This effectiveness is determined by Table 6-2 of this section. All air distribution is performed by cool air distributed from the ceiling giving a zone air distribution effectiveness of 1.
- **V_{oz}** is defined as the zone outdoor airflow. This airflow is the outdoor airflow that must be distributed to the zone via the supply air distribution system. This flow rate is found using the equation:

$$V_{oz} = V_{bz}/E_z$$

- **V_{pz}** is defined as the zone primary airflow. This airflow was taken from the mechanical ductwork floor plans showing the airflow distributed by the diffusers.
- **Z_p** is defined as the primary outdoor air fraction. This fraction used in conjunction with Table 6-3 is determined using the equation:

$$Z_p = {}^{V_{oz}}\!/_{V_{pz}}$$

- **E_v** is defined as the system ventilation efficiency. This efficiency is determined by using either Table 6-3 of this section or Appendix B of this standard.
- **V_{ou}** is defined as the uncorrected outdoor air intake. This intake depends on the diversity of the occupancy as well as the required ventilation rates prescribed by this section. This value is adjusted based on diversity, not efficiency. However, since not enough information is known about the diversity, a value of 1 was assumed for this analysis.
- **V_{ot}** is defined as the outdoor air intake. The value of this is found using the equation:

$$V_{ot} = {}^{V_{ou}}\!/_{E_v}$$

Result Analysis

Calculations were performed according to the prescribed calculation method of ASHRAE 62.1 for the required amount of outdoor air required for space ventilation. A summary of the results is shown in the table below, along with a statement of whether or not it complies with this standard. Detailed calculations for each air handler are shown in Appendix B.

Compliance Summary				
	Calculated Outdoor Air	Design Supply Air Flow	Design Minimum Outdoor Air	ASHRAE 62.1 Compliance
AHU-1	8051 cfm	20395 cfm	7000 cfm	No
AHU-2	7250 cfm	20750 cfm	8000 cfm	Yes
AHU-3	2565 cfm	13600 cfm	5300 cfm	Yes
AHU-4	5192 cfm	5800 cfm	3000 cfm	No
AHU-5	3579 cfm	8090 cfm	4500 cfm	Yes

- **AHU-1**

This air handling unit does not comply with ASHRAE Standard 62.1 as calculated. The air handler does not comply with the standard because its primary outdoor air fraction is much too high. This high value required the use of Appendix A to calculate the zone ventilation efficiency instead of simply using Table 6-3. By calculating the zone ventilation efficiency this way it resulted in an outdoor air flow rate greater than that which was designed.

The reason the airflow is much too high is because with the zone population assumed for the area. The vestibule was assumed to be a lobby; therefore the calculations were performed assuming that the maximum number of people in that space at one time is 122 people. Given the size of the space it is very unlikely that high population density will be observed in that zone. It is very likely that the mechanical designer had more information about the occupancy of the space and designed the flow rate based on that instead of Table 6-1. Another cause for this error could be that the diversity of the space was assumed to be zero since no information was given on the time variance of occupancy in this space. More information about the diversity would lead to a more accurate density factor which would result in a calculated outdoor airflow rate closer to that which was designed.

- **AHU-2**

This air handling unit complies very closely with the requirements of ASHRAE Standard 62.1 as calculated.

- **AHU-3**

This air handling unit complies with the requirements of AHSRAE Standard 62.1 as calculated; however the calculated outdoor airflow is significantly less than that which was designed. This discrepancy could be cause by the use of Table 6-1 to determine the zone population for a majority of spaces. Another source for error could come from the lack of information about the diversity of the space. The system designer most likely had more detailed information about the occupancy of the spaces and the diversity than that which is shown in the drawings.

- **AHU-4**

This air handling unit does not comply with the requirements of ASHRAE Standard 62.1, as calculated. The main cause for non-compliance would be both the occupancy and diversity of the space. The space is titled on the drawings as a "multi-purpose" space and the architect describes the spaces as a "cafétourinaseum." The space can be open to or closed off from the cafeteria space, which has its own separate air handler. The primary use of this space is a gymnasium for the children, however for the sake of accuracy the occupancy class was selected to be "multi-purpose/assembly." Also a diversity of 1 was assumed for the space. Without detailed information about the actual diversity it is unknown what the actual factor is, but it is reasonable to believe that the space would not be constantly occupied because gym class doesn't last all day every day and school assemblies are not a daily occurrence.

- **AHU-5**

This air handling unit does comply with the requirements of ASHRAE Standard 62.1, as calculated. Although the results are not exact, they are relatively close. The discrepancy in values can be attributed to the use of Table 6-1 of this standard to calculate the occupancy of most spaces.

ASHRAE 90.1 Compliance Report

ASHRAE Standard 90.1 is the energy standard for buildings with the exception of low-rise residential buildings. Manoa Elementary School is an educational building therefore it qualifies for analysis using this standard. The prescriptive requirements for this standard include the building envelope, mechanical equipment efficiencies, service hot water, power and lighting density. Included below is an analysis of these prescriptive requirements applied to Manoa Elementary School.

5. Building Envelope

Section 5 of this standard is dedicated to describing the performance requirements for a structure's building envelope. These requirements are dependent on both the location of the building and the space conditioning category.

To assess the compliance to this standard, the climate category first needs to be determined. Using Table B-1 in the Normative Appendix B of this standard it was determined that Havertown Pennsylvania, which is situated in Delaware County, is classified as Climate Zone 4A.

The method to be used to analyze the building envelope is detailed in Section 5.5: Prescriptive Building Envelope Option. In order to use this method two prerequisites must be met. Firstly the total vertical fenestration area cannot exceed 40% of the gross wall area. The table below shows that the building, with a total of 16% glazing meets this requirement. The second prerequisite is that skylight fenestration cannot exceed 5% of the gross roof area. Manoa Elementary School does not have any skylights, therefore this requirement is met. Because both of these prerequisites are met, the building envelope can be analyzed using the Prescriptive Building Envelope Option.

Window Area Summary			
	Fenestration Area	Wall Area	% Glazing
Walls	7,052	44,336	16%
Roof	-	49,650	0%

Manoa Elementary School falls into the "non-residential" occupancy class and the entire building is conditioned. Using this information along with the climate zone and method described above, the maximum U-, C- and F-factors for opaque surfaces can be determined using Table 5.5-4 of this section. Compliance of the designed insulation compared to the prescribed insulation values can be seen in the table below. Actual envelope construction is as follows:

- **Exterior Walls:** 8" CMU, ½" sheathing, 2" R-10 rigid insulation, 3" airspace , 4" face brick
- **Glazing:** Double pained, argon filled and Low-E4 coating for a maximum U-value of 0.35and Solar Heat Gain Coefficient of 0.37.
- **Roof:** 2" acoustic deck, ½" cover board, 2 layers of tapered 2" R-10 rigid insulation, ¼" cover board, modified bitumen roof system.

Insulation Requirements			
	Required	Designed	Compliance
Wall R- Value	9.5	11	Yes
Roof R-Value	20	14	No
Fenestration U-Value	0.55	0.35	Yes
Fenestration Max SHGF	0.4	0.37	Yes

Although both the walls and the vertical fenestration meet the requirements of this standard, the insulation value of the walls could be increased for better performance. The roof, however, does not meet the required value. Further analysis and design of the roof is needed before compliance to this standard can be made.

6. Heating Ventilating and Air-Conditioning

Section 6 of ASHRAE Standard 90.1 prescribes the minimum efficiencies for the mechanical equipment in a newly constructed building as well as the thickness of piping insulation. There are two analysis paths outlined in this standard. The first path requires the building square footage to be less than 25,000 square feet. Manoa Elementary School is much larger than this and therefore must be analyzed using the prescriptive path.

Using the tables in this standard, the tables below show that the majority of air cooled air conditioners does not meet the standard where as all of the split system air handlers do in fact meet this requirement. The reason the air handling units do not meet this standard may be due to the large pressure drop across the filters. The boilers used in the building are dual-fuel boilers and the table cannot be used to analyze them, however according to Section 6.4.1 of this standard, the use of equipment not listed in the tables is okay.

Air Conditioners, air-cooled			
Symbol	Designed SEER	Required SEER	Compliance
ACCU-1	10.0	10	Yes
ACCU-2	10.0	10	Yes
ACCU-3	10.0	10	Yes
ACCU-4	10.0	10	Yes
ACCU-5	10.0	10	Yes

Air Conditioners, air-cooled			
Symbol	Designed EER	Required EER	Compliance
AHU-1	9.6	9.2	Yes
AHU-2	9.6	9.2	Yes
AHU-3	8.0	9.3	No
AHU-4	7.4	9.3	No
AHU-5	6.7	9.3	No

Pipe Insulation				
	Nominal Pipe Diameter	Required Insulation Thickness	Designed Insulation Thickness	Compliance
Heating Systems 141-200˚ Operating Temp	<1"	1	1.5	Yes
	1 to 1-1/2"	1	1.5	Yes
Domestic and Hot Water Service Systems	<1"	0.5	1	Yes
	1 to 1-1/2"	0.5	1	Yes
	1-1/2" to 4"	1	1	Yes
Cooling Systems 40-60˚ Operating Temp	<1"	0.5	1	Yes
	1 to 1-1/2"	0.5	1	Yes

7. Service Hot Water Heating

Section 7 of ASHRAE Standard 90.1 gives a prescriptive method to analyze the building's service hot water heating system. This standard prescribes an 80% efficiency for a hot-water gas and oil supply boiler. The designed system consists of two 79% efficient boilers, which does not meet the requirement of this standard.

8. Power

This section prescribes the allowable voltage drop for a building's power system. The building designer designed based on this standard and sized all feeders and branch circuits to comply with the required 2% and 3% respective voltage drops at the design load.

9. Lighting

This standard defines the maximum allowable lighting power densities allowable for a specific building type. This section outlines two means of analysis: the building area method which allows you to give one specific lighting power density value for the building as a whole and the Space-by-Space method which defines a specific lighting power density for each specific space and the usage is analyzed based on that. If the requirements of the analysis are not met by using the building area method, then the space-by-space method is used to get more specific results. Table 9.5.1 of this section classifies Manoa Elementary School in the school/university category. Compliance with this standard can be seen in the table below:

Lighting Power Density Analysis

	Total Designed Watts	Square Footage	LPD Designed	Maximum from Standard	Compliance
First Floor	47,756	46,833	1.0	1.2	Yes
Second Floor	19,060	24,393	0.8	1.2	Yes
Third Floor	18,086	16,809	1.1	1.2	Yes
Total	**84,902**	**88,035**	**0.96**	**1.2**	**Yes**

As shown in the results, Manoa Elementary School performs much better than what is prescribed in this standard. Because the building area method resulted in a lighting power density much lower than the maximum allowable, the more detailed space-by-space analysis is not required.

References

ASHRAE. 2007, ANSI/ASHRAE, Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

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Appendix A

Natural Ventilation Opening Size Analysis					
Room		Window Area	Floor Area	Percent	Acceptable
101 & 103	SE-1 Classroom	91	860	11%	Yes
105	SE-6 Resource Classroom	91	852	11%	Yes
107	First Grade Classroom	91	873	10%	Yes
109	First Grade Classroom	91	878	10%	Yes
117	First Grade Classroom	91	856	11%	Yes
119	First Grade Classroom	91	846	11%	Yes
102 & 104	SEM Classroom	91	862	11%	Yes
106	Kindergarten Classroom	91	1258	7%	Yes
112	Kindergarten Classroom	91	1161	8%	Yes
118	Kindergarten Classroom	91	1244	7%	Yes
140	Principal Office	43	206	21%	Yes
139	1st	21	160	13%	Yes
136	Guidance	21	160	13%	Yes
135	Conference	85	202	42%	Yes
134	Conference	21	90	24%	Yes
132.2	Exam	21	67	32%	Yes
201	SE-3	26	853	3%	No
205	Second Grade Classroom	88	893	10%	Yes
209	Second Grade Classroom	88	856	10%	Yes
213	Second Grade Classroom	88	871	10%	Yes
215	SEM Classroom	44	432	10%	Yes
217	Gifted SEM	44	448	10%	Yes
225	Third Grade Classroom	88	859	10%	Yes
227	SE-2 Classroom	88	908	10%	Yes
202	Second Grade Classroom	11	853	1%	No
210	Second Grade Classroom	88	904	10%	Yes
214	Third Grade Classroom	88	871	10%	Yes
216	Seminar Learning Support	44	216	20%	Yes
218	Seminar Learning Support	44	464	9%	Yes
224	Third Grade Classroom	88	859	10%	Yes
226	Storage	44	468	9%	Yes
301	SE-4	33	853	4%	Yes
305	Fifth Grade Classroom	88	893	10%	Yes
309	Fifth Grade Classroom	88	856	10%	Yes
313	Fifth Grade Classroom	88	874	10%	Yes
315	Reading/Seminar	44	413	11%	Yes
317	Speech and Language Seminar Room	44	464	9%	Yes
325	Fourth Grade Classroom	88	859	10%	Yes
327	SE-5 Classroom	88	908	10%	Yes
302	Fifth Grade Classroom	22	853	3%	No
310	Fifth Grade Classroom	88	904	10%	Yes
314	Fourth Grade Classroom	88	871	10%	Yes
316	SE Classroom	88	877	10%	Yes
324	Fourth Grade Classroom	88	859	10%	Yes
326	Storage	44	468	9%	Yes

Appendix B

Included in this appendix are the calculation methods used to determine the required outdoor air intake. For each air handler, highlighted in blue is the space requiring the largest primary outdoor air fraction.

AHU-1

Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Zp	Evz
101	SE-1 Classroom	Classrooms (ages 5-8)	860	19	10	0.12	190	103	293	600	0.49	0.9
102	SEM-2 Classroom	Classrooms (ages 5-8)	862	19	10	0.12	190	103	293	500	0.59	0.8
103	SEM Classroom	Classrooms (ages 5-8)	385	14	10	0.12	140	46	186	600	0.31	1.08
104	SEM-3 Classroom	Classrooms (ages 5-8)	486	14	10	0.12	140	58	198	500	0.40	0.99
105	SE-6 Classroom	Classrooms (ages 5-8)	852	25	10	0.12	250	102	352	1200	0.29	1.09
106	Kindergarten Classroom 1	Classrooms (ages 5-8)	1258	26	10	0.12	260	151	411	1200	0.34	1.04
111	Corridor	Corridors	922	0	0	0.06	0	55	55	200	0.28	1.11
124	Faculty Work Room	Break Rooms	408	10	5	0.06	51	24	75	350	0.22	1.17
126	**Vestibule**	**Lobbies**	**816**	**122**	**5**	**0.06**	**612**	**49**	**661**	**615**	**1.07**	**0.31**
301	SE-4 Classroom	Classrooms (ages 5-8)	853	29	10	0.12	290	102	392	1000	0.39	0.99
302	Fifth Grade Classroom 2	Classrooms (ages 5-8)	853	29	10	0.12	290	102	392	1000	0.39	0.99
304	Storage	Storage Rooms	242	0	0	0.12	0	29	29	100	0.29	1.1
305	Fifth Grade Classroom 1	Classrooms (age 9 plus)	893	33	10	0.12	330	107	437	1200	0.36	1.02
306	Girls Restroom	Storage Rooms	208	0	0	0.12	0	25	25	100	0.25	1.14
307/318	Corridor	Corridors	2545	0	0	0.12	0	305	305	400	0.76	1.01
308	Boys Restroom	Storage Rooms	206	0	0	0.12	0	25	25	100	0.25	1.14
309	Fifth Grade Classroom 3	Classrooms (age 9 plus)	856	25	10	0.12	250	103	353	1200	0.29	1.09
310	Fifth Grade Classroom 1	Classrooms (age 9 plus)	904	33	10	0.12	330	108	438	1000	0.44	0.95
313	Fourth Grade Classroom 3	Classrooms (age 9 plus)	874	33	10	0.12	330	105	435	1200	0.36	1.02
314	Fourth Grade Classroom 4	Classrooms (age 9 plus)	871	33	10	0.12	330	105	435	1000	0.43	0.95
315	Reading Seminar	Classrooms (age 9 plus)	413	13	10	0.12	130	50	180	600	0.30	1.09
316	SE Classroom	Classrooms (age 9 plus)	877	30	10	0.12	300	105	405	1200	0.34	1.05
317	Speech & Language Seminar	Classrooms (age 9 plus)	464	17	10	0.12	170	56	226	600	0.38	1.01
322	Faculty Meeting	Conference/Meeting	140	7	5	0.06	35	8	43	140	0.31	1.08
323	Faculty Planning	Conference/Meeting	140	7	5	0.06	35	8	43	140	0.31	1.08
324	Fourth Grade Classroom 2	Classrooms (age 9 plus)	859	33	10	0.12	330	103	433	1000	0.43	0.95
325	Fourth Grade Classroom 1	Classrooms (age 9 plus)	859	33	10	0.12	330	103	433	1200	0.36	1.03
326	Storage	Storage Rooms	468	0	0	0.12	0	56	56	250	0.22	1.16
327	SE-5 Classroom	Classrooms (age 9 plus)	908	33	10	0.12	330	109	439	1200	0.37	1.02

Vou=∑Voz	8051
Vps=∑Vpz	20395
Xs=Vou/Vps	0.39
Ev=min (Evz)	0.31
Vot=Vou/Ev	25972

AHU-2												
Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Zp	Evz
107	First Grade Classroom 1	Classrooms (ages 5-8)	873	33	10	0.12	330	105	435	1200	0.36	1.16
109	First Grade Classroom 2	Classrooms (ages 5-8)	878	33	10	0.12	330	105	435	1200	0.36	0.99
112	Kindergarten Classroom 2	Classrooms (ages 5-8)	1161	30	10	0.12	300	139	439	1200	0.37	0.99
113	Conference	Conference/Meeting	100	5	5	0.06	25	6	31	100	0.31	1.04
115	Storage	Storage Areas	110	0	0	0.12	0	13	13	100	0.13	1.22
117	First Grade Classroom 3	Classrooms (ages 5-8)	856	33	10	0.12	330	103	433	1200	0.36	0.99
118	Kindergarten Classroom 3	Classrooms (ages 5-8)	1244	30	10	0.12	300	149	449	1200	0.37	0.98
119	First Grade Classroom 4	Classrooms (ages 5-8)	846	29	10	0.12	290	102	392	1200	0.33	1.02
120	Faculty Work Room	Break Rooms	120	3	5	0.06	15	7	22	120	0.19	1.17
121	Corridor	Corridors	1260	0	0	0.06	0	76	76	400	0.19	1.16
201	SE-3 Classroom	Classrooms (ages 5-8)	853	29	10	0.12	290	102	392	1500	0.26	1.09
202	Second Grade Classroom 2	Classrooms (ages 5-8)	853	29	10	0.12	290	102	392	1000	0.39	0.96
204	Storage	Storage Areas	242	0	0	0.12	0	29	29	100	0.29	1.06
205	Second Grade Classroom 1	Classrooms (ages 5-8)	893	33	10	0.12	330	107	437	1200	0.36	0.99
206	Girls Restroom	Storage Areas	308	0	0	0.12	0	37	37	100	0.37	0.98
207 & 228	Corridor	Corridors	2547	0	0	0.06	0	153	153	500	0.31	1.04
208	Boys Restroom	Storage Areas	306	0	0	0.12	0	37	37	100	0.37	0.98
210	**Second Grage Classroom 4**	**Classrooms (ages 5-8)**	**904**	**33**	**10**	**0.12**	**330**	**108**	**438**	**1000**	**0.44**	**0.91**
213	Third Grade Classroom 3	Classrooms (ages 5-8)	871	33	10	0.12	330	105	435	1200	0.36	0.99
214	Third Grade Classroom 4	Classrooms (ages 5-8)	871	33	10	0.12	330	105	435	1000	0.43	0.92
215	SEM Classroom	Classrooms (ages 5-8)	413	13	10	0.12	130	50	180	600	0.30	1.05
216	Seminar Learning Support	Classrooms (ages 5-8)	413	13	10	0.12	130	50	180	600	0.30	1.05
217	Gifted Seminar	Classrooms (ages 5-8)	464	17	10	0.12	170	56	226	600	0.38	0.97
218	Seminar Learning Support	Classrooms (ages 5-8)	464	17	10	0.12	170	56	226	600	0.38	0.97
222	Faculty Meeting	Conference/Meeting	140	7	5	0.06	35	8	43	140	0.31	1.04
223	Faculty Planning	Conference/Meeting	140	7	5	0.06	35	8	43	140	0.31	1.04
224	Third Grade Classroom 3	Classrooms (ages 5-8)	859	29	10	0.12	290	103	393	1000	0.39	0.96
225	Third Grade Classroom 1	Classrooms (ages 5-8)	859	29	10	0.12	290	103	393	1200	0.33	1.02
226	Storage	Storage Areas	468	0	0	0.12	0	56	56	250	0.22	1.13
227	SE-2 Classroom	Classrooms (ages 5-8)	908	33	10	0.12	330	109	439	1200	0.37	0.98

Vou=∑Voz	7250
Vps=∑Vpz	20750
Xs=Vou/Vps	0.35
Ev=min (Evz	0.31
Vot=Vou/Ev	23385

AHU-3													
Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Zp	Evz
129	Administration	Office Space	187	1	5	0.06	5	11	16	200	0.08	1.11
130	Reception	Reception Areas	426	5	5	0.06	25	26	51	580	0.09	1.1
131	Hallway	Corridors	126	0	0	0.06	0	8	8	100	0.08	1.11
132	Nurse	Office Space	368	4	5	0.06	20	22	42	275	0.15	1.04
132.2	Exam Room	Office Space	67	1	5	0.06	5	4	9	125	0.07	1.12
133	Hallway	Corridors	210	0	0	0.06	0	13	13	100	0.13	1.06
134	Conference	Conference/Meeting	91	4	5	0.06	20	5	25	175	0.15	1.04
135	Conference	Conference/Meeting	203	14	5	0.06	70	12	82	425	0.19	1
136	Guidence	Office Space	160	7	5	0.06	35	10	45	250	0.18	1.01
139	1st	Office Space	160	5	5	0.06	25	10	35	200	0.17	1.02
140	Principal	Office Space	206	1	5	0.06	5	12	18	500	0.04	1.15
141	Corridor	Corridors	744	0	0	0.06	0	45	45	200	0.22	0.97
142	Library	Libraries	2701	62	5	0.12	310	324	634	2895	0.22	0.97
142.1	Storage	Storage Rooms	184	0	0	0.12	0	22	22	75	0.29	0.89
143	Office	Office Space	181	2	5	0.06	10	11	21	150	0.14	1.05
144	IT Work Room	Office Space	162	1	5	0.06	4	10	14	225	0.06	1.13
145	Music Room	Music/Theater/Dance	882	31	10	0.06	310	53	363	1400	0.26	0.93
145.1	Storage	Storage Rooms	217	0	0	0.12	0	26	26	100	0.26	0.93
146	Faculty Dining	Break Rooms	345	9	5	0.06	43	21	64	600	0.11	1.08
147	Music Room	Music/Theater/Dance	863	30	10	0.06	302	52	354	1200	0.29	0.89
147.1	Storage	Storage Rooms	217	0	0	0.12	0	26	26	100	0.26	0.93
149	**Art Room**	**Art Classroom**	**960**	**31**	**10**	**0.18**	**310**	**173**	**483**	**1200**	**0.40**	**0.79**
149.1	Art Storage	Storage Rooms	119	0	0	0.12	0	14	14	75	0.19	1
150	Corridor	Corridors	1730	0	0	0.06	0	104	104	1075	0.10	1.09
151	Corridor	Corridors	750	0	0	0.06	0	45	45	1275	0.04	1.15
152.1	Gym Office	Office Space	103	1	5	0.06	3	6	9	100	0.09	1.1

Vou=∑Voz	2565
Vps=∑Vpz	13600
Xs=Vou/Vps	0.19
Ev=min (Evz	0.31
Vot=Vou/Ev	8274

AHU-4

Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Zp	Evz
152	Multipurpose Room	Multipurpose Assembly	5408	649	8	0.06	4867	324	5192	5800	0.90	1

Vou=∑Voz	5192
Vps=∑Vpz	5800
Xs=Vou/Vps	0.90
Ev=min (Evz	0.31
Vot=Vou/Ev	16747

AHU-5

Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Zp	Evz
155	Ramp	Corridor	371	0	0	0.06	0	22	22	150	0.15	0.81
156	Cafeteria	Cafeteria/Fast-food dining	1726	104	8	0.18	780	311	1091	1880	0.58	1.29
158	LCI	Cafeteria/Fast-food dining	1714	88	8	0.18	660	309	969	3420	0.28	1.16
159	Serving	Cafeteria/Fast-food dining	574	57	8	0.18	431	103	534	840	0.64	0.81
160	Kitchen	Cafeteria/Fast-food dining	815	82	8	0.18	611	147	758	1000	0.76	0.68
161	**Dish Wash**	**Cafeteria/Fast-food dining**	**149**	**15**	**8**	**0.18**	**112**	**27**	**139**	**100**	**1.39**	**0.06**
163	Office	Office Space	51	0	5	0.06	1	3	4	100	0.04	1.4
164	Dry Storage	Storage Rooms	78	0	0	0.12	0	9	9	100	0.09	1.35
166	Locker	Storage Rooms	84	0	0	0.12	0	10	10	100	0.10	1.34
168	Corridor	Corridor	627	0	0	0.06	0	38	38	300	0.13	1.32
169	Janitors Office	Office Space	64	0	5	0.06	2	4	5	100	0.05	1.39

Vou=∑Voz	3579
Vps=∑Vpz	8090
Xs=Vou/Vps	0.44
Ev=min (Evz	0.31
Vot=Vou/Ev	11544