ASHRAE 62.1 Ventilation Compliance Evaluation

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George W. Hays PK-8

Cincinnati Public School

Cincinnati, OH

Prepared For

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Table of Contents

Executive Summary

This report investigates the adequacy of outdoor air for the George W. Hays Public School in Cincinnati. To do this the designed values of outdoor air (OA) were compared against values determined using ASHRAE Standard 62.1-2004 ventilation requirements at design conditions. The Ventilation Rate Calculation Procedure was used and is found in Section 6 of Standard 62.1. This procedure is based on floor area, number of occupants, space category, and the air distribution system.

The structure contains three Air Handling Units (AHU's) that are responsible for supplying OA to every space in the building. AHU-1 serves the three story classroom wing of the building. AHU-2 serves 1st and 2nd floor classrooms. AHU-3 serves the gymnasium and the gymnasium support areas.

It was found that AHU-1 and AHU-2 do not meet the OA requirements of ASHRAE 62.1, while AHU-3 did meet the required minimum OA. AHU-1 is significantly under ventilated while AHU-2 is near ventilation requirements. Both of these discrepancies can be traced to different assumptions about the required OA design conditions and about OA requirements to particular zones. AHU-3 meet the requirements because of one dominating space for which design assumptions and calculated assumptions were similar.

The OA to the building was based on OA requirements of the Ohio Mechanical Code that only have a per person or per sq ft OA requirement. ASHRAE Std. 62.1-2004 has a required OA per person and per sq ft for each space. This requirement is to account for potential pollutants that may be produced from components of the room other then people. Because of the discrepancies between the OBC and ASHRAE 62.1 OA requirements for 62.1 were not meet for the George W. Hays Public School.

Assumptions

- **No smoking –** There will be no smoking in any areas of the building or near OA intake locations.
- **Acceptable OA –** The Regional and Local Air OA Quality is acceptable for supply and complies with ASHRAE 62.1 Section 4.
- **No Noxious or Dangerous Return Air –** Any noxious or dangerous air that may be generated in the building will be exhausted directly with a sufficient fume hood and will not enter the return air.
- **A_z= .9 A_{gross} –** For each zone, the "Breathing Zone" Area, A_z, was estimated to be 90% of the net floor area in each space. This assumption is to allow for a two foot parameter around the room that is, by definition, not considered part of the Breathing Zone. This assumption was tested with the largest zone because the 90% assumption would be most likely to be proven wrong in a large rectangular space. The largest zone was the Gymnasium, with room dimensions of 84'x71', giving a total area of 5960 ft^2. This was put in contrast with a space having walls 80'x67' to fit the defined Occupied Zone. This area was found to be 5360 ft^2, 89.9% of the room area. Thus it was concluded that the 90% assumption was safe in all smaller spaces.
- **E_z= 1 –** Zone distribution effectiveness, E_z accounts for the ability of the zone to properly mix the supply air with the room air. E_z for each zone was given a value of 1.0 in accordance with Table 6.2 Std. 62.1. All zones have a ceiling supply of cold air, where OA values were found using cooling airflow rates.
- **D_1 can be solved for –** Diversity values for AHU-1 (serving the main classroom wing of the building) could be found by subtracting out populations of zones with local conference and meeting uses from the sum of the population of each individual zone. This value was made the Peak System Population. It was assumed that the local conference areas would only hold populations coming from different zones exclusively from AHU-1. This assumption is further backed up by the Peak System Population in AHU-1 having a lower value then the total design student population for the entire building. The zones that qualified as "local conference and meeting rooms," were:

  Teachers Preps; Rooms 111, 209, & 303
  Extended Learning Areas; Rooms 113, 120, 211, 218, 305
  Workroom / Conference; 304
- **D_2 & D_3 are 1.0 –** The diversity for AHU-2 & AHU-3 was assumed to be 1.0. Conference and meeting zones in AHU-2 and AHU-3 were not subtracted to

find a diversity value because those populations were assumed to be coming from outside the building or from other AHU's.

- **V_{dzmin} = .6 V_{dzmax} –** It was assumed that the minimum expected value of supply to each terminal device during full occupation was equal to 60% of the maximum expected airflow. The minimum setting of 40% on each VAV was not used since this setting is not expected with full occupancy, because the building has a small envelope load and many loads dependant on occupancy, such as lighting and computers. This is further proven because in many of the spaces, such as Rm 113, the minimum VAV setting, 360 cfm is less then the designed OA of 390. This implies that the minimum setting of the VAV was not intended for use during occupancy hours.
- **$OA_{bathrooms}$= 0 –** It was assumed that all restrooms were exhaust only and did not require an OA supply.
- **$OA_{closets}$= 0 –** It was assumed that all small janitor's closets too small to have an occupancy did not require an OA supply.
- ASHRAE Std. 62.1 was interpreted in such a way that default values for persons in a zone were left as fractions when the equation did not equal a round number.
- In rooms where the design occupancy was lower then seemed reasonable, the ASHRAE 62.1 default value was used. For example, conference room 304, 157 sq. ft. was designed for 1 person. This value was discarded for being unreasonable and the ASHRAE default value of 6.85 was used.
- The following tables list assumptions for OA flow rate values, space populations, and Space types used in accordance with 62.1 Table 6.1. The criteria for the selection of OA flow rate values and space populations is also shown. ASHRAE refers to values found in Table 6.1 in ASHRAE Std. 62.1. All space square footages are shown in the respective Appendix.

AHU-3

			Pz		Rp	Ra	
ZONE LEVEL	Room Number	Space Type	Room Population	Population Criteria	OA Rate	OA Rate	Air Rate Criteria
Gymnasium	105	Corridors	525	DRAWINGS	7.5	0.06	ASHRAE
Outdoor Storage	135	Reception	0	DRAWINGS	0	0.12	ASHRAE
P.E. Office	105F	Office Space	0	DRAWINGS	5	0.06	ASHRAE
Faculty Shower	105G	Office Space	39	DRAWINGS	0	0.12	ASHRAE
Girl's Locker Room	105E	Storage	0	DRAWINGS	0	0.12	ASHRAE
Boy's Locer Room	105B	Storage	0	DRAWINGS	0	0.12	ASHRAE
Workroom/Storage	105A	Conference	2	DRAWINGS	10	0.18	ASHRAE
Mechanical Room	228	Office Space	0	DRAWINGS	0	0.12	ASHRAE

AHU-1

			Pz		Rp	Ra	
ZONE LEVEL	Room Number	Space Type	Room Population	Population Criteria	OA Rate	OA Rate	Air Rate Criteria
Teacher's Prep	111	Conference	14.2	ASHRAE	5	0.06	ASHRAE
Corridor	107	Corridors	0	Drawings	0	0.06	ASHRAE
Mechanical	111A	Storage Room	0	Drawings	0	0.12	ASHRAE
Instructional Storage	112	Storage Room	0	Drawings	0	0.12	ASHRAE
Extended Learning Area	113	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom First Grade	114	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom First Grade	115	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom First Grade	116	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom First Grade	177	Classroom	26	Drawings	10	0.12	ASHRAE
Corridor	118	Corridors	0	Drawings	0	0.06	ASHRAE
Extended Learning Area	120	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Kindergarten	121	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Kindergarten	122	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Kindergarten	123	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Kindergarten	124	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Pre-Kindergarten	125	Classroom	26	Drawings	10	0.12	ASHRAE
Corridor	203	Corridors	0	Drawings	0	0.06	ASHRAE
Teacher's Prep	209	Conference	15.8	ASHRAE	5	0.06	ASHRAE
Instructional Storage	210	Storage Room	0	Drawings	0	0.12	ASHRAE
Extended Learning Area	211	Classroom	26	Drawings	10	0.12	ASHRAE
Self Contained Classroom	212	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	213	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	214	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	215	Classroom	26	Drawings	10	0.12	ASHRAE
Corridor	216	Corridors	0	Drawings	0	0.06	ASHRAE
Extended Learning Area	218	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	219	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	220	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	221	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 2-5	222	Classroom	26	Drawings	10	0.12	ASHRAE
Corridor	302	Corridors	0	Drawings	0	0.06	ASHRAE
Teacher's Prep	303	Conference	14.05	ASHRAE	5	0.06	ASHRAE
Workroom / Conference	304	Conference	6.85	ASHRAE	5	0.06	ASHRAE
Instructional Storage	305	Storage Room	0	Drawings	0	0.12	ASHRAE
Extended Learning Area	306	Classroom	26	Drawings	10	0.12	ASHRAE
Special Ed Resource	307	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 6-8	308	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 6-8	309	Classroom	26	Drawings	10	0.12	ASHRAE
Classroom Grades 6-8	310	Classroom	26	Drawings	10	0.12	ASHRAE
Corridor	312	Corridors	0	Drawings	0	0.06	ASHRAE
Mechanical Room	313	Storage Room	0	Drawings	0	0.12	ASHRAE

AHU-2

			Pz		Rp	Ra	
ZONE LEVEL	Room Number	Space Type	Room Population	Population Criteria	OA Rate	OA Rate	Air Rate Criteria
Corridor	104, 104N	Corridors	0	DRAWING	0	0.06	ASHRAE
Reception	104A	Reception	6	DRAWING	5	0.06	ASHRAE
Secretarial	104B	Office Space	2	DRAWING	5	0.06	ASHRAE
Health Clinic	104C	Office Space	3	DRAWING	5	0.06	ASHRAE
Laundry	104D	Coin Operating	0.936	ASHRAE	7.5	0.06	ASHRAE
Principle	104E	Office Space	1	DRAWING	5	0.06	ASHRAE
Conference	104F	Conference	6	DRAWING	5	0.06	ASHRAE
Itinerate Staff	104G	Office Space	1	DRAWING	5	0.06	ASHRAE
Mail/Copy	104H	Office Space	1	DRAWING	5	0.06	ASHRAE
Administrative Storage	104K	Storage Room	0	DRAWING	0	0.12	ASHRAE
Vault/Records	104M	Storage Room	0	DRAWING	0	0.12	ASHRAE
In-School Suspension	104R	Classroom	6	DRAWING	10	0.12	ASHRAE
Parent Volunteer	104S	Office Space	1	DRAWING	5	0.06	ASHRAE
Corridor	105	Corridors	0	DRAWING	0	0.06	ASHRAE
Community Room	126	Classroom	8	DRAWING	10	0.12	ASHRAE
Student Dining	127	Cafeteria	75	DRAWING	7.5	0.18	ASHRAE
Table Storage	127A	Storage Room	0	DRAWING	0	0.12	ASHRAE
Platform	128	Multi-Use Area	26	DRAWING	7.5	0.06	ASHRAE
Serving and Kitchen Prep	129, 129G	Cafeteria	10	DRAWING	7.5	0.18	ASHRAE
Ware Washing	129A	Cafeteria	1	DRAWING	7.5	0.18	ASHRAE
Locker Room	129B	Storage Room	0	DRAWING	0	0.12	ASHRAE
Dietician Office	129D	Office Space	1	DRAWING	5	0.06	ASHRAE
Dry Food Storage	129F	Storage Room	0	DRAWING	0	0.12	ASHRAE
Corridor	130	Corridors	0	DRAWING	0	0.06	ASHRAE
Loading/Receiving	130A	Shipping/Receiving	0	DRAWING	0	0.12	ASHRAE
Custodial Office	131	Office Space	1	DRAWING	5	0.06	ASHRAE
Central Storage	132	Storage Room	0	DRAWING	0	0.12	ASHRAE
Workroom	133	Wood/metal	2	DRAWING	10	0.18	ASHRAE
Mechanical / Electrical	133A	Storage Room	0	DRAWING	0	0.12	ASHRAE
Central Storage	134	Storage Room	0	DRAWING	0	0.12	ASHRAE
Corridor	202	Corridors	0	DRAWING	0	0.06	ASHRAE
Entry, Stair and Corridor	101, 102, 201	Corridors	0	DRAWING	0	0.06	ASHRAE
Computer Lab	204	Computer	28	DRAWING	10	0.12	ASHRAE
Reading Room	205	Classroom	21	DRAWING	10	0.12	ASHRAE
Conference	205A	Conference	5	DRAWING	5	0.06	ASHRAE
Media Specialist	205B	Office Space	1	DRAWING	5	0.06	ASHRAE
Workroom/Storage	205C	Wood/metal	1	DRAWING	10	0.18	ASHRAE
Tech Control Center	205D	Media Center	2	DRAWING	10	0.12	ASHRAE
A.V. Storage	205E	Storage Room	0	DRAWING	0	0.12	ASHRAE
Science Classroom	223	Science lab	26	DRAWING	10	0.18	ASHRAE
Art Room	224	Art Classroom	26	DRAWING	10	0.18	ASHRAE
Art Material Storage	224A	Storage Room	0	DRAWING	0	0.12	ASHRAE
Kiln/Ceramic Storage	224B	Storage Room	0	DRAWING	0	0.12	ASHRAE
Instrumental Classroom	225	Music/Theater	33	DRAWING	10	0.06	ASHRAE
Music Room Storage	225A	Storage Room	0	DRAWING	0	0.12	ASHRAE
Mechanical	226	Storage Room	0	DRAWING	0	0.12	ASHRAE

Procedures

The building was broken up into three main zones. Each of the three air handling units were made responsible for supplying an appropriate amount of Outdoor Air (OA) to each zone. To determine the minimum OA, Section 6 of ASHRAE Standard 62.1-2004 was used. The calculations for determining the minimum amount of required outdoor air were similar for each of the three zones and went in acquaintance with the following steps.

STEP 1: ADDITIVITY

Equations Used:

$V_{bz} = R_p*P_z + R_a*A_z$ (Equation 6-1)

Definitions:

V_{bz} = CFM required for the breathing Zone.

R_p = CFM required per person for the Zone.

R_a = CFM required per square foot of the Zone.

P_z = Number of people expected in the zone.

A_z = Area of the breathing zone

Breathing Zone- The region within an occupied space between planes 3 and 72 inches above the floor and more than 2 ft from the walls or fixed air-conditioning equipment. (Section 3, Std. 62.1)

Discussion:

All values for A_z were determined to be 90% of the total room area (See assumptions).

All values for R_p and R_a were determined using Table 6.1 of Std. 62.1.

In determining P_z, spaces where the known occupancy appeared on documents, P_z was set to the known occupancy. In cases with no record of known occupancy or with values of occupancies seeming questionably low values for P_z were determined using Table 6.1 of Std. 62.1 (See assumptions).

STEP 2: ZONE OUTDOOR AIRFLOW

Equations Used:

$V_{oz} = V_{bz}/E_z$ (Equation 6-2)

Definitions:

E_z = Ratio of the airflow entering the breathing zone to the airflow delivered to the diffusers.

V_{oz} = OA that must reach the zone in order to supply a proper amount of OA to the breathing zone, considering distribution effectiveness.

Discussion:

E_z values were all assumed to be 1.0 by using Table 6.2 of Std. 62.1. (See assumptions).

STEP 3: DISCHARGE OA FRACTION

Equations Used:

$Z_d = V_{oz} / V_{pzmin}$ (By Definition, Appendix A)

Definitions:

Z_d = Fraction of OA in the primary airflow to a zone (also referred to as Z_d).

V_{pzmin} = Minimum expected primary supply airflow to a zone.

Discussion:

V_{pzmin} values were found from analyzing system, drawings, and schedules (See assumptions).

STEP 4: UNCORRECTED OA INTAKE

Equations Used:

D= Peak System Population / ∑ Peak Zone Populations (Equation 6-7)

$V_{ou} = D^* \sum(R_p{*}P_z) + \sum(R_a{*}A_z)$ (Equation 6-6)

Definitions:

D = Population diversity for the zones served by the AHU.

V_{ou} = Uncorrected OA intake flow for all zones, not adjusted for ventilation efficiency, E_v.

Discussion:

Diversity values for AHU-2 & AHU-3 were estimated to be 1.0 (See assumptions). The diversity for AHU-1 was determined by subtracting out the populations of zones that were expected to only contain occupants from other zones still served by AHU-1 from the sum of each individual zone. This value was assumed to be the peak system population (See assumptions).

STEP 5: CRITICAL ZONE VENTILATION EFFICIENCY (APPENDIX A)

Equations Used:

$X_s = V_{ou} / V_{ps}$ (By Definition, Appendix A)

$V_{ps} = \sum V_{pz}$ (By Definition, Appendix A)

$F_a = E_p + (1-E_p)*E_r$ (By Definition, Appendix A)

$E_p = V_{pz}/V_{dz}$ (By Definition, Appendix A)

$F_b = E_p$ (By Definition, Appendix A)

$F_c = 1-(1-E_z)$ (By Definition, Appendix A. **Note:** there are other components to this equation however; they are all multiplied by $(1-E_z)$. Because of the assumption that E_z in every space is equal to 1.0, these other terms are multiplied by zero.

$E_{vz} = (F_a + X_s * F_b – Z_d * F_c) / F_a$ (Equation A-2)

$E_v = \min[E_{vz}]$ (By Definition, Appendix A)

Definitions:

X_s = Uncorrected average outdoor-air intake fraction.

V_{ps} = Total system primary airflow

E_{vz} = Zone ventilation efficiency

E_v = Critical zone ventilation efficiency

Discussion:

Equation A-2 was used, regardless of E_v or the system setup. Because it was known that E_v would not be within the range of Table 6-3, and that Table 6-3 makes the assumption of Z_p being an average of .15 for reasons of uniformity and accuracy Appendix A was used for each system. Since, A-2 covers scenarios in A-2 and A-1, for uniformity equation A-2 was used for each system.

STEP: TOTAL OA INTAKE FLOW

Equations Used:

$V_{ot} = V_{ou} / E_v$ (Equation 6-8)

Definitions:

V_{ot} = Total intake OA flow adjusted for ventilation efficiency.

Discussion:

V_{ot} for each AHU is the total value of OA required for the system. This value was then compared with the design values of OA to determine if the minimum OA values were met.

Sample Calculations

STEP 1: ADDITIVITY

$V_{bz} = R_p*P_z + R_a*A_z$ (Equation 6-1)

$V_{bz} = 260 + 119.556 = 379.556$

STEP 2: ZONE OUTDOOR AIRFLOW

$V_{oz} = V_{bz}/E_z$ (Equation 6-2)

$V_{oz} = 379.556/1.0 = 379.556$

STEP 3: DISCHARGE OA FRACTION

$Z_d = V_{oz}/V_{pzmin}$ (From Appendix A, ASHRAE 62.1)

$Z_d = 379.556/50 = 7.59112$

STEP 4: UNCORRECTED OA INTAKE

D= Peak System Population / ∑ Peak Zone Populations (Equation 6-7)

The only System for which a diversity value was calculated was for AHU-1 (See assumptions).

∑ Peak Zone Populations=727

Peak System Population= 727- Populations of local conference zones

=727 – (14.2+26+26+15.8+26+26+14.05+6.85+26)

=727 – 181

=546

D= 546/727= 0.75

$V_{ou} = D* \sum(R_p*P_z) + \sum(R_a*A_z)$ (Equation 6-6)

V_{ou} = 0.75* 7014.5+ 2731.266 = 8000

STEP 5: CRITICAL ZONE VENTILATION EFFICIENCY (APPENDIX A)

(See assumptions)

$V_{ps} = \sum V_{pz}$ (By definition, Std. 62n Appendix A)

$V_{ps} = 27190$

$X_s = V_{ou} / V_{ps}$ (By definition, Std. 62n Appendix A)

$X_s = 8000 / 27190 = 0.294226$

$E_p = V_{pz}/V_{dz}$

$E_p = 900/900 = 1.0$

$F_a = E_p + (1-E_p)*E_r$

$F_a = 1.0 + 0 = 1.0$

$F_b = E_p$

$F_b = 1.0$

$F_c = 1-(1-E_z)$

$F_c = 1-(1-1) = 1.0$

$E_{vz} = (F_a + X_s * F_b – Z_d * F_c) / F_a$

$E_{vz} = (1.0 + 0.294226 * 1.0 – 0.7 * 1.0) / 1.0 = 0.594226$

$E_v = \min[E_{vz}]$

$E_v = 0.59$

STEP 6: TOTAL OA INTAKE FLOW

$V_{ot} = V_{ou} / E_v$

$V_{ot} = 8000/ 0.59 = 13546$

System and Building Summary

Total Building Summary and Findings

The building is broken up into three main zones. Each of the three air handling units is responsible for supplying an appropriate amount of Outdoor Air (OA) to its respective zone. Each zone is mainly limited to a particular type of space. This helps keep the critical space representative of the space, because the minimum E_{vz} from Appendix A can be expected to be somewhat similar for spaces serving a similar function with similar OA requirements. Thus, limiting the amount of OA brought to unnecessary spaces. Each zone is served by one AHU. Each AHU is an indoor modular Air Handling Unit located in a mechanical room or mezzanine. Each AHU has an integral heat recovery wheel, a return or relief fan, an economizer section, heating and cooling coil and a supply fan. The zone breakups according to AHU are shown in Table 5-1.

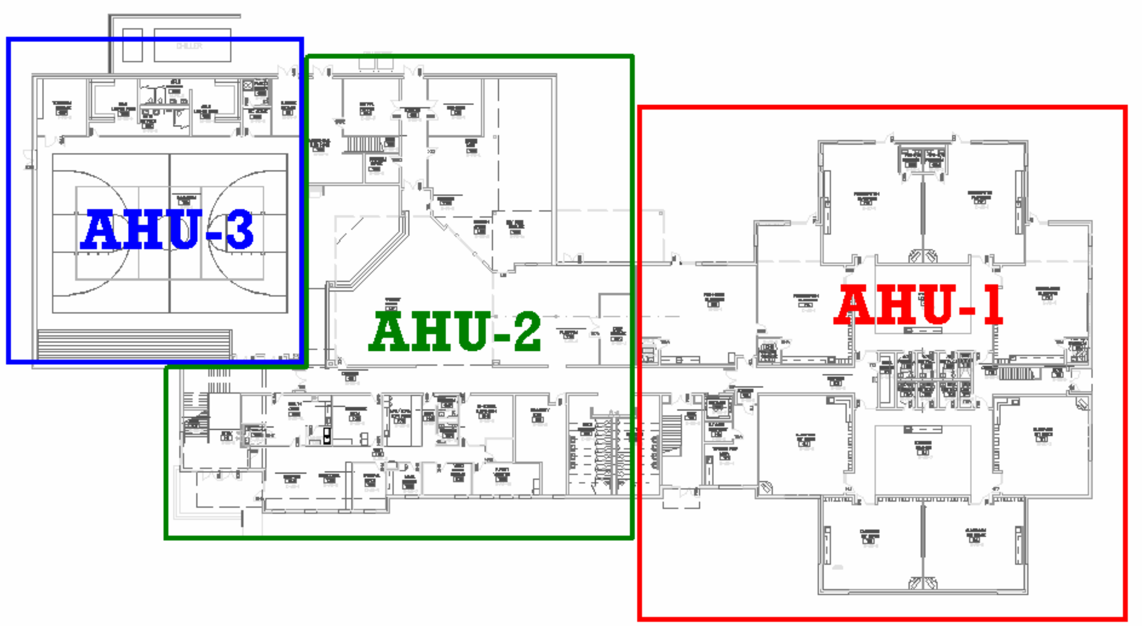

TABLE 5-1
Air Handling Unit Zone Distribution

Table 5-2 further describes these zones by room types and total area. These are the Net areas, or "Breathing Zone" areas used for calculations (See assumptions). Table 5-2 also highlights the basic comparisons between the

designed OA flow and the ASHRAE 62.1 calculated OA flow which will be looked at more ineptly in the subsequent sections. Specific data for each AHU is laid out in Appendices A-C

Unit	Type	Zone Served	Net Area Served [Sq. ft]	Calculated OA [CFM]	Calculated OA Intake Percentage	Designed OA [CFM]
AHU-1	VAV	Three story classroom wing	24,700	13,529	50%	11,066
AHU-2	VAV	1st and 2nd floor classrooms and auxiliary areas	19,100	9,078	40%	8,296
AHU-3	VAV	Gymnasium and the gymnasium support areas	6,900	6,535	51%	8,632

TABLE 5-2
Air Handling Unit Summary

The sum of the V_{oz} values in all zones served by AHU-1, AHU-2, and AHU-3 was 18,890, or 65% of the some of the V_{ot} values of 29,142 cfm. The reason for this increase is the critical zone requiring a higher fraction of OA then some of the other zones. In order to supply a sufficient amount of OA to the critical space, the system is forced to supply excess OA to non-critical spaces.

AHU-1

Air Handling Unit 1 supplies the three-story classroom wing of the building. The exact division between AHU-1 and AHU-2 is between the Pre-Kindergarten classroom 125 and the Platform room 126. This line also continues through a men's and a women's bathroom, neither of which require ventilation (See assumptions).

AHU-1 complies with section 5 of ASHRAE Std 62.1. The OA intake is on an elevated vertical wall in a location free from the potential contaminant sources detailed in Table 5-1 of 62.1.

The sum of the V_{oz} values in the zones served by AHU-1 was 9,746, or 72% of the V_{ot} value of 13,529 cfm. The reason that this percentage is higher then the percentage for the entire building is due to two major components; the diversity factor applied to this space and critical Z_d value in this space being somewhat representative of the other spaces served by AHU-1.

The OA fraction, Z_d (the equivalent to Z_p but for Appendix A) for the critical space was 0.7. Because calculations were done using Appendix A, the

minimum E_{vz} was the value that determined the critical space, not the maximum Z_p. For AHU-1 the minimum value for E_{vz} was 0.59 from the Extended Learning Area rooms: 113, 120, 211, 218, and 306. This value represents a dense population and low envelope, resulting in a high OA%.

The net area served by AHU-1 is 24,700 ft^2. This gross area, (including walls and spaces not in the Breathing Zone or not in spaces requiring OA) is 31662 ft^2. The design OA CFM was 11,066, with 50% OA, only 82% of the calculated OA required to meet Standard 62.1 of 13,529.

This discrepancy is mainly due to a difference in procedure and base assumptions. The design conditions for selecting OA were originally under maximum load conditions, not V_{dzmin}. As noted in the Assumptions, there were also differences between the design and the calculated occupancies.

The designed OA flow would be even a smaller proportion of the calculated OA flow but, the Ohio Mechanical Code (O.M.C.) in general requires significantly more OA in each space. For example, a Conference room under the O.M.C. would require 20 cfm/person, where under ASHRAE 62.1 there is a requirement of just 5 cfm/person and .06 cfm/sq ft. This is displayed in Conference room 304, containing 6.85 people and an area of 123 ft^2. Using Equation 6-6, the comparison becomes as follows:

O.M.C.
20 cfm/per * 6.85 per * 0.75 = 103 cfm

ASHRAE 62.1
5 cfm/per * 6.85 * 0.75 + .06 cfm/sq ft * 123 sq ft = 33 cfm

Because of these offsetting differences, both the designed OA flow and the calculated OA flow found an OA percentage of 50%. This somewhat high OA percentage, as stated, is due to a low envelope and high population density.

AHU-2

Air Handling Unit 2 supplies a two story office and auxiliary classrooms wing of the building serving a net area of 19,100 sq ft. The total area of this zone is 21,451 sq ft.

AHU-2 complies with section 5 of ASHRAE Std. 62.1. The OA intake is on a roof, but elevated more then 1 ft above the roof, meeting the requirements of Table 5-1 of 62.1.

The sum of the V_{oz} values in the zones served by AHU-2 was 4,678, or 52% of the V_{ot} value of 9,078 cfm. The reason for this large difference in values is due to no diversity factor being applied for the space, and the critical zone not being representative of the other zones served by AHU-2.

The OA fraction, Z_d for the critical space was 0.87.

The design OA was 46% of the total flow rate or 8,296 cfm. Similar to AHU-1, this value is only 91% of the 9,078 cfm calculated. The reasons for this discrepancy are like those mapped out for AHU-1 and because of differing OA requirements at the critical space. The design assumed 20 cfm/per for a workshop, Room 133, resulting in 40 cfm. From ASHRAE 62.1 it was assumed 10 cfm/per and .18 cfm/sq ft for a workshop resulting in 73 cfm of OA. This OA requirement caused the E_{vs} to become 0.31, making Room 133 the critical zone. The next lowest E_{vs} value was 0.41, Room 224. If the workshop, Room 133, was supplied OA by another unit or by other means, the E_v value for the system would be 0.41. The resulting OA would then be 6872 cfm (See Appendix B) reducing the required OA by 76%, allowing the current design to meet with ASHRAE 62.1.

The percentage OA calculated was 40%, which is comparable to the 46% designed. The lower OA percentages in this wing of the building are because of more offices or other low density occupancies.

AHU-3

Air Handling Unit 3 supplies the Gymnasium and Gymnasium support areas. The net area of these spaces is 6,900 sq ft with a gross area of 8,844 sq ft.

AHU-3 complies with section 5 of ASHRAE Std 62.1. The OA intake is on an elevated vertical wall in a location free from the potential contaminant sources detailed in Table 5-1 of 62.1.

The sum of the V_{oz} values in the zones served by AHU-3 was 4,466, or 68% of the V_{ot} value of 6,535 cfm. This value falls inline with the average of all three AHU's.

The critical space served by AHU-3 was the Gymnasium, Room 105, with a E_{vs} value of 0.68. As shown in the assumptions, the gymnasium was assumed to be entirely a spectator area, and not a play area. This is because of the potential of large gatherings using the gymnasium as a seating area. This assumption resulted in a dense population, increasing the percent OA required for the zone.

The design OA was for 8,632 cfm compared with a 6,535 calculated cfm or 51% OA. This AHU is the only one that meets ASHRAE 62.1 OA requirements. This is because of one dominating space in the zone, the gymnasium at 5443 sq ft or 79% of the total zone served by AHU-3. The design assumption found on documents stated that the Gymnasium would receive 15 cfm/ per, which is comparable to 7.5 cfm/ per and .06 cfm/sq ft.

DISCUSSION

ASHRAE 62.1-2004 highlights two procedures for determining OA. For this analysis the Ventilation Rate Procedure (VRP) from Section 6.2 was used. However, an alternative method in Section 6.3 is called the Indoor Air Quality Procedure (IAQP). Both methods strive to archive a moderation of contaminants in space and supplying adequate amounts of OA, but are implemented in different ways.

The VRP used in this analysis applies OA values per sq ft and per person determined by ASHRAE to maintain a quality of air acceptable for occupants. This value is based on an estimated amount of toxic or unpleasant fumes released into the space by components or objects in the room, such as computers and wall paint as well as well as estimated CO_2 released by occupants. ASHRAE assumes that by knowing the area of a space, the general properties of the space, and the number of people in a space, a value of OA can be obtained to maintain good indoor air quality.

The IAQP of Section 6.3 is done by using a reasonable method of testing the indoor air quality of the space to determine the amount of OA required for maintaining acceptable space conditions. This method involves an in-depth study on the materials in the space to determine the amount of toxins expected to be released. Once the building is constructed this method requires a constant monitoring of the zones. One potential danger of this system is a poor upkeep in sensors used to determine the indoor air quality. If these instruments are not maintained properly, then there is no guarantee of an adequate supply of OA. However, this method allows for a decrease in OA to spaces shown to have low containment levels resulting in a minimization of excess OA, thus providing energy savings. There is also the potential for maintaining a good indoor air quality in situations where a contaminant is released under low occupancy and load conditions. Where in the VRP an insufficient amount of OA may be supplied to the space, the IAQP has the potential for detecting the containment and supplying adequate OA.

If the IAQP were implemented in this building a more in-depth knowledge about the furniture and components of the spaces would need to be known. This procedure would also create potential problems for any renovations introducing paints or furniture that was not intended to be in the space. However, for the Gymnasium portion section of the wing the IAQP has a potential for better IAQ in the space and reduced energy costs by supplying less OA when the space is unoccupied. Because the Gymnasium has a relatively predictable usage with predictable containments the IAQP could potentially be a reasonable method for analyzing the OA requirements. If further research was conducted, and this method was implemented for the Gymnasium it would be possible to reduce OA requirements and save energy while ensuring a consistent indoor air quality, if the monitoring systems could be properly maintained.

APPENDIX A

AHU-1

ZONE LEVEL

ROOM NAME	Teacher's Prep	Corridor	MECHANICAL	Instructional Storage	Extended Learning Area
RM NUMBER	111	107	111A	112	113
ASHRAE GROUP	Conference / meeting	Corridors	Storage rooms	Storage rooms	Classrooms (ages 5-8)
Az	255.6	311.4	40.5	62.1	996.3
Pz	14.2	0	0	0	26
Rp	5	0	0	0	10
Ra	0.06	0.06	0.12	0.12	0.12
Pz*Rp	71	0	0	0	260
Az*Ra	15.336	18.684	4.86	7.452	119.556
Voz	86.336	18.684	4.86	7.452	379.556
Vpz	340	80	290	50	900
Vdz	340	80	290	50	900
Vdzm	204	48	174	30	540
Zd	0.42	0.39	0.03	0.25	0.70
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs		0.9	1.27	1.05	0.59

ZONE LEVEL

ROOM NAME	Classroom First Grade	Classroom First Grade	Classroom First Grade	Classroom First Grade	Corridor
RM NUMBER	114	115	116	117	118
ASHRAE GROUP	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Corridors
Az	729	729	729	729	82.8
Pz	26	26	26	26	0
Rp	10	10	10	10	0
Ra	0.12	0.12	0.12	0.12	0.06
Pz*Rp	260	260	260	260	0
Az*Ra	87.48	87.48	87.48	87.48	4.968
Voz	347.48	347.48	347.48	347.48	4.968
Vpz	960	920	950	930	50
Vdz	960	920	950	930	50
Vdzm	576	552	570	558	30
Zd	0.60	0.63	0.61	0.62	0.17
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.69	0.66	0.68	0.67	1.13

ZONE LEVEL

ROOM NAME	Extended Learning Area	Classroom Kindergarten	Classroom Kindergarten	Classroom Kindergarten	Classroom Kindergarten
RM NUMBER	120	121	122	123	124
ASHRAE GROUP	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)
Az	996.3	866.7	868.5	868.5	866.7
Pz	26	26	26	26	26
Rp	10	10	10	10	10
Ra	0.12	0.12	0.12	0.12	0.12
Pz*Rp	260	260	260	260	260
Az*Ra	119.556	104.004	104.22	104.22	104.004
Voz	379.556	364.004	364.22	364.22	364.004
Vpz	900	1000	900	890	900
Vdz	900	1000	900	890	900
Vdzm	540	600	540	534	540
Zd	0.70	0.61	0.67	0.68	0.67
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.59	0.69	0.62	0.61	0.62

ZONE LEVEL

ROOM NAME	Classroom Pre-Kindergarten	Corridor	Teacher's Prep	Instructional Storage	Extended Learning Area
RM NUMBER	125	203	209	210	211
ASHRAE GROUP	Classrooms (ages 5-8)	Corridors	Conference / meeting	Storage rooms	Classrooms (ages 5-8)
Az	866.7	505.8	232.2	67.5	996.3
Pz	26	0	15.8	0	26
Rp	10	0	5	0	10
Ra	0.12	0.06	0.06	0.12	0.12
Pz*Rp	260	0	79	0	260
Az*Ra	104.004	30.348	13.932	8.1	119.556
Voz	364.004	30.348	92.932	8.1	379.556
Vpz	920	230	340	50	900
Vdz	920	230	340	50	900
Vdzm	552	138	204	30	540
Zd	0.66	0.22	0.46	0.27	0.70
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.63	1.07	0.84	1.02	0.59

ZONE LEVEL

ROOM NAME	Self Contained Classroom	Classroom Grades 2-5	Classroom Grades 2-5	Classroom Grades 2-5	Corridor
RM NUMBER	212	213	214	215	216
ASHRAE GROUP	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Corridors
Az	729.9	729	729	729	82.8
Pz	26	26	26	26	0
Rp	10	10	10	10	0
Ra	0.12	0.12	0.12	0.12	0.06
Pz*Rp	260	260	260	260	0
Az*Ra	87.588	87.48	87.48	87.48	4.968
Voz	347.588	347.48	347.48	347.48	4.968
Vpz	960	920	950	930	300
Vdz	960	920	950	930	300
Vdzm	576	552	570	558	180
Zd	0.60	0.63	0.61	0.62	0.03
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.69	0.66	0.68	0.67	1.27

ZONE LEVEL

ROOM NAME	Extended Learning Area	Classroom Grades 2-5	Classroom Grades 2-5	Classroom Grades 2-5	Classroom Grades 2-5
RM NUMBER	218	219	220	221	222
ASHRAE GROUP	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)
Az	996.3	737.1	729	729	729
Pz	26	26	26	26	26
Rp	10	10	10	10	10
Ra	0.12	0.12	0.12	0.12	0.12
Pz*Rp	260	260	260	260	260
Az*Ra	119.556	88.452	87.48	87.48	87.48
Voz	379.556	348.452	347.48	347.48	347.48
Vpz	900	890	900	900	900
Vdz	900	890	900	900	900
Vdzm	540	534	540	540	540
Zd	0.70	0.65	0.64	0.64	0.64
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.59	0.64	0.65	0.65	0.65

ZONE LEVEL

ROOM NAME	Corridor	Teachers Prep	Workroom/ Conference	Instructional Storage	Extended Learning Area
RM NUMBER	302	303	304	305	306
ASHRAE GROUP	Corridors	Conference / meeting	Conference / meeting	Storage rooms	Classrooms (ages 5-8)
Az	588.6	252.9	123.3	85.5	996.3
Pz	0	14.05	6.85	0	26
Rp	0	5	5	0	10
Ra	0.06	0.06	0.06	0.12	0.12
Pz*Rp	0	70.25	34.25	0	260
Az*Ra	35.316	15.174	7.398	10.26	119.556
Voz	35.316	85.424	41.648	10.26	379.556
Vpz	210	300	160	100	900
Vdz	210	300	160	100	900
Vdzm	126	180	96	60	540
Zd	0.28	0.47	0.43	0.17	0.70
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	1.01	0.82	0.86	1.12	0.59

ZONE LEVEL

ROOM NAME	Special Ed Resource	Classroom Grades 6-8	Classroom Grades 6-8	Classroom Grades 6-8	Corridor	Mechanical Room
RM NUMBER	307	308	309	310	312	313
ASHRAE GROUP	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Classrooms (ages 5-8)	Corridors	Storage rooms
Az	729	729	729	729	85.5	939.6
Pz	26	26	26	26	0	0
Rp	10	10	10	10	0	0
Ra	0.12	0.12	0.12	0.12	0.06	0.06
Pz*Rp	260	260	260	260	0	0
Az*Ra	87.48	87.48	87.48	87.48	5.13	30.348
Voz	347.48	347.48	347.48	347.48	5.13	30.348
Vpz	960	920	950	930	250	460
Vdz	960	920	950	930	250	460
Vdzm	576	552	570	558	150	276
Zd	0.60	0.63	0.61	0.62	0.03	0.11
Ep	1.00	1.00	1.00	1.00	1.00	1.00
Er						
Ez	1.00	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00	1.00
Evs	0.69	0.66	0.68	0.67	1.26	1.18

SYSTEM LEVEL

Ps	546			
D	0.75			
Vou	8000			
Vps	27190			
Xs	0.29			
SYSTEM EFFICIENCY				
Evs	0.87			
Ev	0.59			
		Percent outdoor air intake		
Vot	**13529**		**50%**	= Vot/Vps

APPENDIX B

AHU-2

ZONE LEVEL

	Corridor	Reception	Secretarial	Health Clinic	Laundry	Principal
	104, 104N	104A	104B	104C	104D	104E
Az	355.5	175.5	252	341.1	46.8	150.3
Pz	0	6	2	3	0.936	1
Rp	0	5	5	5	7.5	5
Ra	0.06	0.06	0.06	0.06	0.06	0.06
Pz*Rp	0	30	10	15	7.02	5
Az*Ra	21.33	10.53	15.12	20.466	2.808	9.018
Voz	21.33	40.53	25.12	35.466	9.828	14.018
Vpz	80	270	270	210	50	150
Vdz	80	270	270	210	50	150
Vdzm	48	162	162	126	30	90
Zd	0.44	0.25	0.16	0.28	0.33	0.16
Ep	1.00	1.00	1.00	1.00	1.00	1.00
Er						
Ez	1.00	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00	1.00
Evs	0.68	0.87	0.97	0.84	0.80	0.97

ZONE LEVEL

	Conference	Itinerate Staff	Mail/ Copy	Administrative Storage	Vault/ Records
	104E	**104G**	**104H**	**104K**	**104M**
Az	216	87.3	172.8	128.7	64.8
Pz	6	1	1	0	0
Rp	5	5	5	0	0
Ra	0.06	0.06	0.06	0.12	0.12
Pz*Rp	30	5	5	0	0
Az*Ra	12.96	5.238	10.368	15.444	7.776
Voz	42.96	10.238	15.368	15.444	7.776
Vpz	230	100	160	100	100
Vdz	230	100	160	100	100
Vdzm	138	60	96	60	60
Zd	0.31	0.17	0.16	0.26	0.13
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.81	0.95	0.96	0.87	0.99

ZONE LEVEL

	In-School Suspension	Parent Volunteer	Corridor	Community Room	Student Dining
	104R	**104S**	**105**	**126**	**127**
Az	212.4	184.5	878.4	358.2	2178
Pz	6	1	0	8	75
Rp	10	5	0	10	7.5
Ra	0.12	0.06	0.06	0.12	0.18
Pz*Rp	60	5	0	80	562.5
Az*Ra	25.488	11.07	52.704	42.984	392.04
Voz	85.488	16.07	52.704	122.984	954.54
Vpz	230	260	200	300	4000
Vdz	230	260	200	300	4000
Vdzm	138	156	120	180	2400
Zd	0.62	0.10	0.44	0.68	0.40
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.50	1.02	0.68	0.44	0.73

ZONE LEVEL

	Table Storage	Platform	Serving and Kitchen Prep	Ware Washing	Locker Room
	127A	128	129, 129G	129A	129B
Az	248.4	761.4	976.5	153	72
Pz	0	26	10	1	0
Rp	0	7.5	7.5	7.5	0
Ra	0.12	0.06	0.18	0.18	0.12
Pz*Rp	0	195	75	7.5	0
Az*Ra	29.808	45.684	175.77	27.54	8.64
Voz	29.808	240.684	250.77	35.04	8.64
Vpz	300	940	3000	150	110
Vdz	300	940	3000	150	110
Vdzm	180	564	1800	90	66
Zd	0.17	0.43	0.14	0.39	0.13
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.96	0.70	0.98	0.73	0.99

ZONE LEVEL

	Dietician Office	Dry Food Storage	Corridor	Loading/ Receiving	Custodial Office
	129D	**129F**	**130**	**130A**	**131**
Az	72.9	175.5	104.4	93.6	87.3
Pz	1	0	0	0	1
Rp	5	0	0	0	5
Ra	0.06	0.12	0.06	0.12	0.06
Pz*Rp	5	0	0	0	5
Az*Ra	4.374	21.06	6.264	11.232	5.238
Voz	9.374	21.06	6.264	11.232	10.238
Vpz	100	150	150	150	125
Vdz	100	150	150	150	125
Vdzm	60	90	90	90	75
Zd	0.16	0.23	0.07	0.12	0.14
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.97	0.89	1.05	1.00	0.99

ZONE LEVEL

	Central Storage	Work Room	Mechcnical / Electrical	Central Storage	Corridor
	132	**133**	**133A**	**134**	**202**
Az	94.5	295.2	261	173.7	1167.3
Pz	0	2	0	0	0
Rp	0	10	0	0	0
Ra	0.12	0.18	0.12	0.12	0.06
Pz*Rp	0	20	0	0	0
Az*Ra	11.34	53.136	31.32	20.844	70.038
Voz	11.34	73.136	31.32	20.844	70.038
Vpz	125	150	150	150	330
Vdz	125	150	150	150	330
Vdzm	75	90	90	90	198
Zd	0.15	0.81	0.35	0.23	0.35
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.97	0.31	0.77	0.89	0.77

ZONE LEVEL

	Entry, Stair and Corridor	Computer Lab	Reading Room	Conference	Media Specialist
	101, 102, 201	204	205	205A	205B
Az	661.5	919.8	1071	187.2	107.1
Pz	0	28	21	5	1
Rp	0	10	10	5	5
Ra	0.06	0.12	0.12	0.06	0.06
Pz*Rp	0	280	210	25	5
Az*Ra	39.69	110.376	128.52	11.232	6.426
Voz	39.69	390.376	338.52	36.232	11.426
Vpz	1500	1880	1575	200	100
Vdz	1500	1880	1575	200	100
Vdzm	900	1128	945	120	60
Zd	0.04	0.35	0.36	0.30	0.19
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	1.08	0.78	0.76	0.82	0.93

ZONE LEVEL

	Workroom/ Storage	Tech Control Center	A.V. Storage	Science Classroom	Art Room
	205C	**205D**	**205E**	**223**	**224**
Az	137.7	333	173.7	809.1	807.3
Pz	1	2	0	26	26
Rp	10	10	0	10	10
Ra	0.18	0.12	0.12	0.18	0.18
Pz*Rp	10	20	0	260	260
Az*Ra	24.786	39.96	20.844	145.638	145.314
Voz	34.786	59.96	20.844	405.638	405.314
Vpz	120	160	100	1020	950
Vdz	120	160	100	1020	950
Vdzm	72	96	60	612	570
Zd	0.48	0.62	0.35	0.66	0.71
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.64	0.50	0.78	0.46	0.41

ZONE LEVEL

	Art Material Storage	Kiln/ Ceramic Storage	Instrumental Classroom	Music Room Storage	Mechanical
	224A	**224B**	**225**	**225A**	**226**
Az	113.4	100.8	1205.1	189	1008.9
Pz	0	0	33	0	0
Rp	0	0	10	0	0
Ra	0.12	0.12	0.06	0.12	0.12
Pz*Rp	0	0	330	0	0
Az*Ra	13.608	12.096	72.306	22.68	121.068
Voz	13.608	12.096	402.306	22.68	121.068
Vpz	75	100	1440	150	450
Vdz	75	100	1440	150	450
Vdzm	45	60	864	90	270
Zd	0.30	0.20	0.47	0.25	0.45
Ep	1.00	1.00	1.00	1.00	1.00
Er					
Ez	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00
Evs	0.82	0.92	0.66	0.87	0.67

SYSTEM LEVEL

Ps	80			
D	0.27			
Vou	2818			
Vps	22910			
Xs	0.12			
SYSTEM EFFICIENCY				
Zone ventilation efficiency, (Fa				
Ev	0.31			
			Percent outdoor air intake	
Vot	**9079**		**40%**	= Vot/Vps

ALTERNATIVE SYSTEM, E_v = 0.413 (SEE AHU-2 SECTION OF SYSTEM AND BUILDING SUMMARY.)

Ps	System population, maximum simultaneous # of occupants of space served by system	80				
D	Occupant diversity, ratio of system peak occupancy to sum of space peak occupancies, = Ps/ΣPz	0.27				
Vou	Uncorrected outdoor air intake, = D*ΣRp*Pz +ΣRa*Az, cfm	2818				
Vps	Total system primary flow to all zones, Σ Vpz, cfm	22910				
Xs	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = Vou/Vps	0.12				
SYSTEM EFFICIENCY						
Ev	System ventilation efficiency, min(Evs)	0.41				
				Percent outdoor air intake		
Vot	**Minimum outdoor air intake, Vou/Ev, cfm**	**6872**		**30%**	= Vot/Vps	

APPENDIX C

AHU-3

ZONE LEVEL	Gymnasium	Outdoor Storage	P.E. Office	Faculty Shower	Girl's Locker Room	Boy's Locker Room	Workroom/ Storage	Mechanical
	105	**135**	**105F**	**105G**	**105E**	**105B**	**105A**	**228**
	Spectator areas	Storage rooms	Office space	Storage rooms	Storage rooms	Storage rooms	Wood/metal shop	Storage rooms
Az	5443.2	105	48	39	160.2	160.2	165.6	782.4
Pz	525	0	0	39	0	0	2	0
Rp	7.5	0	5	0	0	0	10	0
Ra	0.06	0.12	0.06	0.12	0.12	0.12	0.18	0.12
Pz*Rp	3937.5	0	0	0	0	0	20	0
Az*Ra	326.592	12.6	2.88	4.68	19.224	19.224	29.808	93.888
Voz	4264.092	12.6	2.88	4.68	19.224	19.224	49.808	93.888
Vpz	10,650	130	100	120	200	200	410	925
Vdz	10,650	130	100	120	200	200	410	925
Vdzm	6,390	78	60	72	120	120	246	555
Zd	0.67	0.16	0.05	0.07	0.16	0.16	0.20	0.17
Ep	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Er								
Ez	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fa	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SYSTEM LEVEL								
Ps	566							
D	1.00							
Vou	4466							
Vps	12735	**Note: In VAV systems, Vps is equal to the fan airflow, and the formula in cell c40 needs to be replaced by this value.**						
Xs	0.35							
SYSTEM EFFICIENCY								
Evs	0.68	1.19	1.30	1.29	1.19	1.19	1.15	1.18
Ev	0.68							
			Percent outdoor air intake					
Vot	**6535**		**51%**	= Vot/Vps				

Bibliography

"ANSI/ASHRAE Standard 62.1-2004". American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA. 2004.

"62.1 User's Manual ANSI/ASHRAE Standard 62.1-2004". American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA. 2005.