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DEA Clandestine Laboratory Training Center
Quantico Marine Corps Base, Quantico, VA

Mechanical Technical Report 1

ASHRAE Standard 62.1-2004

Ventilation Rate Procedure

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Executive Summary:

The DEA Clandestine Laboratory Training Center is located on the Quantico Marine Corps Base in Quantico, VA. It is a one-story building with a Mechanical Mezzanine Level that encompasses approximately 34,000 sq ft. The building spaces include multiple function types such as laboratories, classrooms, office space, and physical training areas. ASHRAE Standard 62.1-2004 and the corresponding 2006 Supplement Addenda and User's Manual were used to evaluate the building's ventilation requirements. The findings were then analyzed and compared to the values of the original design.

Several of the spaces analyzed fell outside of the scope of the standard. In these cases, assumptions were made using the information at hand. Considering the variables sure to be inherent in the assumptions made, it is difficult to speak with certainty about the ventilation effectiveness of the current design. While the results showed that some of the systems examined failed to comply with standard, the overall amount of outdoor air being supplied in the original design is on the order of 156% of the amount found to be required by the standard.

Preliminary Discussion:

Mechanical Ventilation System Summary:

Five air handling units (AHU's) located in the Mechanical Mezzanine Level supply the building with conditioned air. Each unit utilizes a draw-through centrifugal supply fan and receives OA ducted from an intake louver. Return air is routed back to the AHU's through the plenum using transfer ducts and some longer duct runs where necessary. The Mechanical Room is both ventilated and pressurized by relief air from AHU's 1 and 3 which then is forced out of relief louvers that are ducted from the Mechanical Room. The Boiler Room has a constant volume (CV) inline centrifugal supply fan that provides the space with OA for both ventilation and combustion air. Three air conditioning units (ACU'S) with separate air-cooled condensing units (ACCU's) serve the LAN Equipment and Electrical Rooms via transfer air from adjacent spaces. The design of the mechanical systems did not make allowances for future expansion. For an illustration of how conditioned air is distributed from the AHU's to the various zones, please see the *AHU Distribution* appendix.

Intended Use of Standard 62.1:

The purpose of ASHRAE Standard 62.1-2004 is to provide adequate ventilation rates and acceptable indoor air quality (IAQ). The goal is to create an environment that minimizes the risk of adverse health effects potentially caused by poor ventilation or harmful contaminants. According to the accompanying User's Manual of Standard 62.1, acceptable IAQ is said to be achieved when "there are no known contaminants at concentrations determined to be harmful to building occupants, as determined by cognizant authorities, and when a substantial majority (80% or more) of those persons exposed to the indoor air do not express dissatisfaction with its quality." If these targets are not reached, however, this does not mean that the system fails to comply with Standard 62.1. Occupant dissatisfaction may stem from other factors not covered in the scope of the standard including, but not limited to, humidity and thermal comfort.

Ventilation Rate vs. Indoor Air Quality Procedure:

As a designer, one can utilize either of two methods detailed in Standard 62.1 to accomplish the aforementioned objectives: the *Ventilation Rate Procedure* or the *Indoor Air Quality Procedure*. The *Ventilation Rate Procedure* (VRP) determines minimum outdoor air (OA) intake rates for given spaces based on expected occupancy, floor area, and function of the spaces in question. The *IAQ Procedure* attempts to arrive at an acceptable concentration of contaminants that is equal to or less than that which would be attained by use of the VRP. It makes use of techniques such as selection of equipment to minimize harmful emissions or contaminant removal. Contributing factors in the design of the *IAQ Procedure* include sources of contaminants in question and their respective strengths, as well as target concentration limits and exposure periods.

The major difference between the two procedures is that the VRP requires a specific amount of OA to be introduced for compliance, while the IAQ method allows any method or combination of methods to be utilized to reach the target concentrations. This means that the two procedures may be used in conjunction with each other to achieve adequate ventilation to typical spaces while still addressing specific contaminant concerns. Another important distinction stems from the fact that the VRP is an indirect approach to achieve acceptable IAQ conditions. It is based on typical contaminant concentrations for the kinds of spaces covered by the standard. If the expected contaminants or spaces in question are not covered in the scope of the VRP, perhaps the IAQ method would be the better choice. In the following sections, the Clandestine Laboratory Training Center will be analyzed using the VRP.

General Assumptions:

- Ambient outdoor air complies with Section 4 of Standard 62.1
- Outdoor air intakes and their locations comply with Section 5.6 of Standard 62.1
- If ambient air quality does not comply with Section 4, it shall be treated in accordance with Section 6.2.1 of Standard 62.1

- Using Table 6-2, the value of *Zone Air Distribution Effectiveness* (E_z) shall be set equal to 0.8 for all zones in question, assuming ceiling supply of warm air 15°F or more above space temperature and ceiling return
- Exception to above: Electrical Room, where only cooling is needed, shall be assigned an E_z of 1.0, assuming ceiling supply of cool air
- *System Population* (P_s) is the estimated maximum number of simultaneous occupants in areas served by the system
- All spaces analyzed shall be assumed to be "no-smoking" areas as noted in Section 6.2.9 of Standard 62.1

AHU-1:

AHU-1 is a Variable-Air-Volume (VAV) unit with economizer that serves Classroom #1-3 and their storage areas, the Conference Room, Break Room, Physical Training, Equipment and Clothing Try-on spaces, the Mock Lab, and Electrical Room. It has been sized to supply a maximum total airflow rate of 9,420 cfm and a minimum outdoor air (OA) rate of 2,280 cfm via a single-duct system with VAV terminal units.

Assumptions:

- Classrooms #1 and 2 are classified under occupant category "Lecture hall (fixed seats) due to their high occupant densities
- Physical Training space shall be classified under occupant category "Health club/aerobics room" due to its high occupant density
- Activity levels in the Equipment Try-on, Clothing Try-on, and Mock Lab spaces are assumed to be similar to the "Multi-use assemblies" occupant category
- *Zone Primary Airflow* (V_{pz}) is equal to 40% of maximum supply airflow (not minimum VAV box capability) as noted in Supply Air Terminal Unit Schedule on drawing M-900 of the design documents
- Single-duct VAV System allows for use of Equation A-1 in calculating *Zone Ventilation Efficiency* (E_{vz}) for Single Supply Systems

Calculation Results and Analysis:

The *Outdoor Air Intake Flow* (V_{ot}) required for AHU-1 was calculated using the Multiple-Zones Recirculating Systems and Appendix A (Single Supply Systems) sections of the Calculation Procedure outlined in this report. According to the required V_{ot} value (a negative number) produced from the attached spreadsheet, the system does not comply with ASHRAE Standard 62.1-2004 *Ventilation Rate Procedure*, nor is it possible for it to meet these requirements under the present set of assumptions in use. A negative V_{ot} value, implying extraction of OA from a space, does not make physical sense in the context of the standard.

The critical spaces that control the calculation (via an equal minimum *Zone Ventilation Efficiency* value) are Classrooms #1 and 2. This minimum E_{vz} value is negative due to the fact that, in the formula, a relatively large value of Z_p is being subtracted. It may appear that Z_p, the *Outdoor Air Fraction*, is significantly large in the classrooms due to large floor areas and high zone populations which drive up *Zone Outdoor Airflow* (V_{oz}), and these are certainly contributing factors. Perhaps the foremost cause, however, is that the *Zone Primary Airflow* (V_{pz}) values are lower than the corresponding V_{oz} in several zones, including the classrooms. This implies that more OA is required to the space than is being supplied under the current set of assumptions and, ultimately, is the reason for the apparent failure to comply with the standard.

Assigning *Zone Primary Airflow* values equal to the true minimum setback (40% of the maximum supply) airflow proved to be a pivotal assumption. It is clear from the discussion above that using these V_{pz} values does not provide an acceptable amount of OA as set forth in the standard under maximum occupancy conditions. Attempting to replace these values with a more realistic design-occupancy airflow may seem like a reasonable alternative. It is difficult, however, to decide upon another V_{pz} value without arbitrarily testing possibilities through many iterations to force the system to comply with the standard.

CO_2-Based Demand-Controlled Ventilation:

All this does not necessarily mean that the original design was flawed. Section 6.2.7 outlines a method known as *Dynamic Reset* or *Demand-Controlled Ventilation* (DCV) in which OA rates can be reduced when occupancy is below the design capacity. When using this technique, occupancy sensors or CO_2 concentration sensors can be utilized to determine how many people are in the zone, and the OA intake can then modulate accordingly. The AHU-1 system employs CO_2 concentration sensors in several of the zones analyzed in this section. These sensors monitor CO_2 levels (an indirect way of measuring zone occupancy) and control OA intake as described in drawing IC-701, 4^{th} column, paragraph M:

> If carbon dioxide level reaches its "increase outside air" level (700ppm above ambient, adjustable) the VAV box primary damper shall modulate open to increase primary airflow to decrease carbon dioxide level.

Appendix A of ASHRAE Standard 62.1-2004 User's Manual suggests several strategies for CO_2-based DCV in multiple-zone, recirculating, single path VAV systems such as AHU-1. Using this appendix, one could determine if the DCV system in use supplies sufficient OA at design occupancy in compliance with the recommendations of the standard. This is beyond the scope of this report.

AHU-2:

AHU-2 is a VAV unit sized at 8,040 cfm that supplies the Analytical Lab and supporting spaces with 100% outdoor air via a single-duct system with VAV air valve units. The Analytical Lab must be maintained at a negative pressure relative to the adjoining rooms, thereby ensuring that harmful fumes do not leak out and permeate the neighboring spaces. The higher relative pressure of adjacent spaces may cause air to seep into the Lab. If this infiltrating air is of poor quality, it will defeat the purpose of supplying 100% outdoor air to the space. Taking this into consideration, the only logical solution is then to supply 100% OA to the adjacent corridor, a somewhat uncommon design practice. This will make certain that only high-quality infiltration reaches the Lab, and explains why a corridor is served by a 100% OA unit.

The Analytical Lab contains several exhaust fume hoods totaling over 6,000 cfm. Using a suggested minimum exhaust rate of 1.00 cfm/ft^2 from Table 6-4, the recommended exhaust rate for the Lab totals only 2,010 cfm, which is considerably less than the actual rate. One could then conclude that a large amount of supply air will be needed just to cover the make-up air requirements of such a space. This zone is then said to be "exhaust driven." These types of spaces, especially when supplied with 100% OA, commonly far exceed the ventilation rate required by Standard 62.1.

Assumptions:

- Glass Wash Room requires same ventilation conditions (*People Outdoor Air Rate* and *Area Outdoor Air Rate*) as Analytical Lab

Calculation Results and Analysis:

The *Outdoor Air Intake Flow* (V_{ot}) required for AHU-2 was calculated using the 100% OA Systems section of the Calculation Procedure outlined in this report. According to the V_{ot} value (1,204 cfm) obtained from the attached spreadsheet, the system easily complies with ASHRAE Standard 62.1-2004 *Ventilation Rate Procedure*. This is typical of exhaust driven spaces such as most laboratories.

The Lab has the most floor area, the most people, and the highest required OA rates per person and per unit area in the system, thereby generating the greatest V_{oz} of the four zones served by AHU-2. Unlike in cases of Multiple-Zone Recirculating Systems, however, no single critical space drives the process. Rather, the *Outdoor Air Intake Flow* (V_{ot}) is simply equal to the sum of the *Zone Outdoor Airflows* ($\sum_{all\ zones} V_{oz}$).

AHU-3:

AHU-3 is a VAV unit with economizer that serves the Open Office, Office Unit Chief, Office Storage, Copy Room, Main Lobby, Firearms Training Systems (F.A.T.S.) Facility, Laundry Room, Clandestine Lab Equipment Room, and several corridors. The largest air handling unit in the building, it has been sized to supply a maximum total airflow rate of 10,880 cfm and a minimum OA rate of 1,310 cfm via a single-duct system with VAV terminal units.

Assumptions:

- Firearms Training Systems Facility shall have *People Outdoor Air Rate*, R_p, of 10 cfm/person and an *Area Outdoor Air Rate*, R_a, of 0.12 cfm/ft^2
- *Zone Primary Airflow*, V_{pz}, is equal to 40% of maximum supply airflow (not minimum VAV box capability) as noted in Supply Air Terminal Unit Schedule on drawing M-900 of the design documents
- Single-duct VAV System allows for use of Equation A-1 in calculating *Zone Ventilation Efficiency*, E_{vz}, for Single Supply Systems
- LAN System Equipment Room shall be classified in the "Telephone closets" occupancy category, and do not require OA
- Main Electrical Equipment Room is ventilated via supply fan in adjacent Boiler Room and easily meets ventilation requirements of 0.06 cfm/ft^2

Calculation Results and Analysis:

The *Outdoor Air Intake Flow* (V_{ot}) required for AHU-3 was calculated using the Multiple-Zones Recirculating Systems and Appendix A (Single Supply Systems) sections of the Calculation Procedure outlined in this report. According to the required V_{ot} value (4,322 cfm) produced in the attached spreadsheet, the system does not comply with ASHRAE Standard 62.1-2004 *Ventilation Rate Procedure*.

The critical space that controls the calculation (via its minimum E_{vz} value and corresponding maximum Z_p) is the F.A.T.S. Facility. Unlike the critical spaces in the AHU-1 system, the F.A.T.S. Facility has neither the largest floor area nor the largest design population of the zones served by AHU-3. Its V_{oz} is surpassed by that of several other zones, most notably the Open Office which contains both the largest area and population. The Open Office's maximum V_{oz} constitutes a major portion of V_{ou}, which has a direct effect on the ultimate value of V_{ot}. However, this V_{ou} is still divided by E_v (equal to E_{vz} value of F.A.T.S. Facility) to arrive at the final OA amount.

Once again, an assumption has proven to be a crucial point in the calculation process. The F.A.T.S. Facility does not fall under one of the occupancy categories of Table 6-1, so it was assigned R_p and R_a values. Adjusting these values slightly can have a large effect on the V_{oz} of the space. A smaller V_{oz} would mean a lower *Zone Primary Outdoor Air Fraction* (holding V_{pz} constant at the minimum setback airflow), and in turn, a higher *System Ventilation Efficiency* of the same space. If the V_{oz} was driven low enough, the F.A.T.S. Facility would cease to have the critical E_{vz} value, and a different zone would drive the calculation.

An important factor in the calculation of OA requirements for AHU-1 was the decision to assign V_{pz} the minimum setback airflow value. For AHU-3 the same assumption was made, producing a similar effect of elevated Z_p values. Unlike with AHU-1, however, CO_2-based DCV is not utilized in this case. With DCV it is possible to supply sufficient OA at design occupancy and then reduce the OA supply at off-peak conditions. Without DCV in AHU-3, supply quantities are driven by space temperature, which is a result of space load. In lower than design load conditions, the supply could be dropped down to the minimum setback point, and it would be possible to deliver insufficient OA to the space.

AHU-4:

AHU-4 is a CV unit that serves the Raid Facility and its supporting Control and Equipment Rooms. It has been sized to supply a constant total airflow rate of 2,090 cfm and a minimum OA rate of 880 cfm via a single-duct system.

Assumptions:

- Raid Facility shall have *People Outdoor Air Rate*, R_p, of 10 cfm/person and an *Area Outdoor Air Rate*, R_a, of 0.06 cfm/ft^2
- Raid Control Room shall be classified under occupant category "Computer (not printing)"

Calculation Results and Analysis:

The *Outdoor Air Intake Flow* (V_{ot}) required for AHU-4 was calculated using the Multiple-Zones Recirculating Systems and Appendix A (Single Supply Systems) sections of the Calculation Procedure outlined in this report. According to the V_{ot} value produced in the attached spreadsheet (827 cfm), the system complies with ASHRAE Standard 62.1-2004 *Ventilation Rate Procedure*.

The critical space that controls the calculation is the Raid Equipment Room (via its minimum E_{vz} value and corresponding maximum Z_p). As with the F.A.T.S. Facility of AHU-3, the Raid Equipment Room has neither the largest floor area nor the largest design population of the zones served by AHU-4. The Raid Facility itself has the largest area and most people of the zones in question, thereby giving it the highest V_{oz} value and making it the other significant contributor to the end OA requirement tabulated.

Also similar to the F.A.T.S. Facility of AHU-3, the Raid Facility was assigned R_p and R_a values because it did not fall under one of the occupant categories of Table 6-1. Adjusting these values slightly could have easily increased the end result OA value and the system would not have complied with the standard.

The fact that AHU-4 is a CV system negated the chance for problems similar to those produced in AHU's 1 and 3, where the V_{pz} was assigned the value equal to the minimum setback position. Supplying a constant airflow, there is only one possible value for V_{pz}.

AHU-5:

AHU-5 is a CV unit that serves the Smokehouse. It has been sized to supply a constant total airflow rate of 560 cfm and a minimum OA rate of 340 cfm via a single-duct system. The purpose of the Smokehouse is to create a smoke-filled environment in which training activities will take place. The smoke will then be purged by a CV fan sized at 560 cfm.

Assumptions:

- Smokehouse shall have *People Outdoor Air Rate*, R_p, of 20 cfm/person and an *Area Outdoor Air Rate*, R_a, of 0.06 cfm/ ft^2

Calculation Results and Analysis:

The *Outdoor Air Intake Flow* (V_{ot}) required for AHU-5 was calculated using the Single-Zone Systems section of the Calculation Procedure outlined in this report. According to the V_{ot} value (434 cfm) obtained from the attached spreadsheet, the system fails to comply with ASHRAE Standard 62.1-2004 *Ventilation Rate Procedure*.

Due to the fact that only one zone was being analyzed here, any assumptions made about the space were sure to have significant effects on the resulting OA requirement obtained. Similar to the F.A.T.S. Facility and Raid Facility, the Smokehouse did not fall under one of the occupant categories of Table 6-1 and was assigned R_p and R_a values. Small changes in these assumed values would greatly affect the end V_{ot} value, possibly resulting in compliance with the standard.

V_{ot} vs. $\sum_{all\ zones} V_{oz}$

When comparing the sum of the *Zone Outdoor Airflows* ($\sum_{all\ zones} V_{oz}$) to the *Outdoor Air Intake Flow* (V_{ot}), several factors come into play to create differing values. V_{oz} is obtained from the *Breathing Zone Outdoor Airflow* being divided by E_z, a factor determined by whether heating or cooling is being performed, and how the air is supplied. The process used to arrive at V_{ot} is dependent upon the type of system in question.

In the Multiple-Zones Recirculating Systems analyzed here, V_{ot} takes the *Diversity Factor* and *System Ventilation Efficiency* (a result of one critical space in the system) into account. Considering the *Diversity Factor* is similar to not sizing an air handling unit equal to the sum of its zone maximum airflows, relying on the assumption that not all spaces will be under design load conditions at the same time. The *Diversity Factor* performs the same function with occupancy of spaces, with the knowledge that the same person cannot occupy two rooms at the same time. The *System Ventilation Efficiency* proves to be the driving factor, however, showing how one space can control the end result of the calculation. Negating the skewed results of AHU-1, all other systems analyzed using the Multiple-Zones Recirculating Systems procedure resulted in $V_{ot} > \sum V_{oz}$ as a result of this.

In AHU-2 where the 100% OA Systems procedure was used, $V_{ot} = \sum V_{oz}$ because factors such as *Zone Primary Outdoor Air Fraction* and *System Ventilation Efficiency* have no effect when 100% OA is being supplied.

For AHU-5 where the Single-Zone Systems procedure was used, $V_{ot} = V_{oz}$ because factors such as the *Diversity Factor* have no effect when only space is being analyzed.

Once again neglecting the results of AHU-1, the total $\sum V_{oz}$ of all the systems is equal to 3,545 cfm and the total V_{ot} is equal to 6,787 cfm. This is consistent with the Multiple-Zones Recirculating Systems of which the building is mostly comprised, in which the total *Outdoor Air Intake Flow* generally exceeded the sum of the *Zone Outdoor Airflows*. The total minimum OA design value (minus AHU-1) is 10,570 cfm, meaning that overall more OA is being supplied than is required by the standard.

Conclusions and Discussion:

As discussed in the previous section, the total minimum OA actually being supplied in the building does surpass that which is required by Standard 62.1. A large chunk of this total is comprised of OA supplied to the Analytical Lab which, by means of exhaust, is isolated from the rest of the building. This excess OA cannot be utilized elsewhere, so although the total supply does exceed the total requirement, any zones that may be under-ventilated receive no benefit from this excess.

Assumptions, particularly those involving *Zone Primary Airflow* and assigning occupancy categories, proved to play major roles in the resulting *Outdoor Air Intake Flow*. While the *Demand-Controlled Ventilation* system in place for AHU-1 can account for the compliance failure caused by assumed V_{pz} values, it is possible that spaces served by AHU-3 could be under-ventilated. As for AHU-5, it is difficult to say that the current amount of OA being supplied is insufficient without more knowledge of the space conditions.

Calculation Procedure:

(Equations and Tables reference Standard 62.1)

All Systems:

Breathing Zone Outdoor Airflow: $V_{bz} = R_p*P_z + R_a*A_z$ (6-1)

R_p = OA rate required per person (Table 6-1)
P_z = Zone population
R_a = OA rate required per unit area (Table 6-1)
A_z = Zone floor area

Zone Air Distribution Effectiveness: E_z obtained from Table 6-2

Zone Outdoor Airflow: $V_{oz} = V_{bz} / E_z$ (6-2)

Single-Zone Systems:

Outdoor Air Intake Flow: $V_{ot} = V_{oz}$ (6-3)

100% OA Systems:

Outdoor Air Intake Flow: $V_{ot} = \sum_{all\ zones} V_{oz}$ (6-4)

Multiple-Zone Recirculating Systems:

Zone Primary Outdoor Air Fraction: $Z_p = V_{oz} / V_{pz}$ (6-5)

Uncorrected Outdoor Air Intake: $V_{ou} = D*\sum(R_p*P_z) + R_a*A_z$ (6-6)

Diversity Factor: $D = P_s / (\sum_{all\ zones} P_z)$ (6-7)

System Ventilation Efficiency: E_v obtained from Table 6-3
(when $Z_p \leq 0.55$)

E_v obtained from Appendix A
(when $Z_p > 0.55$)

Outdoor Air Intake Flow: $V_{ot} = V_{ou} / E_v$ (6-8)

Appendix A (Single Supply Systems):

Zone Ventilation Efficiency: $E_{vz} = 1 + X_s - Z_d$ (A-1)

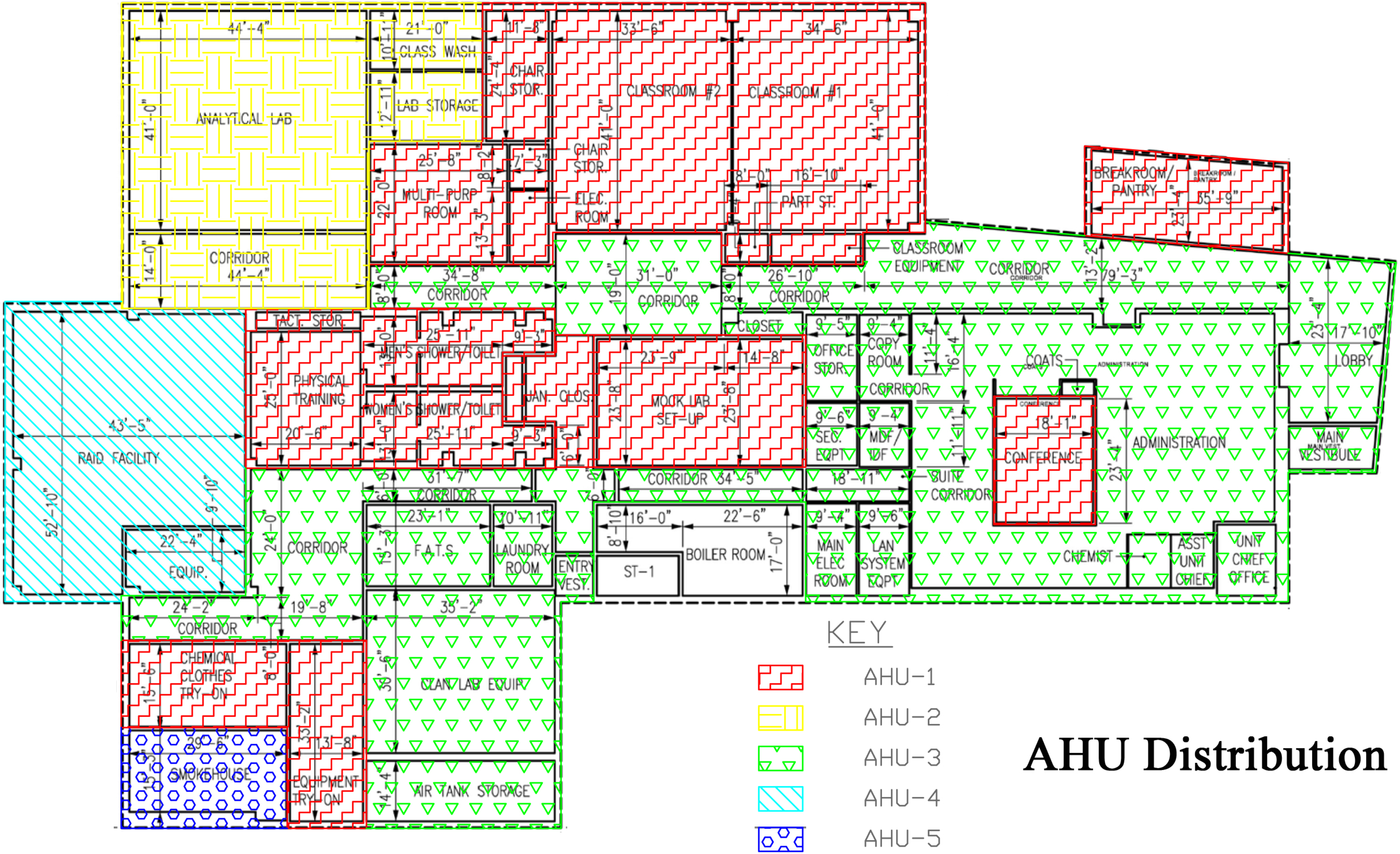
Average Outdoor Air Fraction: $X_s = V_{ou} / V_{ps}$

System Primary Airflow: $V_{ps} = \sum_{\text{all zones}} V_{pz}$

Discharge Outdoor Air Fraction: $Z_d = V_{oz} / V_{dz}$

For Systems in Question: $V_{dz} = V_{pz}$

System Ventilation Efficiency: E_v = minimum E_{vz} value in system



AHU Distribution

AHU-1 (VAV)

Zone	Occupancy Category	Az Floor Area (sq ft)	Pz Population
Classroom #1	Lecture hall (fixed seats)	1400	140
Classroom #2	Lecture hall (fixed seats)	1400	140
Classroom #3 / MPR	Multi-use assembly	565	28
Break Room / Pantry	Break rooms	537	16
Clsrm #1 Equipment	Storage rooms	100	-
Clsrm #2 Chair Storage	Storage rooms	285	-
Conference Room	Conference/meeting	430	22
Physical Training	Health club / aerobics room	465	17
Equipment Try-on	*Assume similar to multi-use*	455	17
Clothing Try-on	*Assume similar to multi-use*	400	17
Mock Lab	*Assume similar to multi-use*	979	17
Electrical Room	Electrical equipment rooms	96	-
Total		**7112**	**414**

AHU-2 (VAV) 100% OA Unit

Zone	Occupancy Category	Az Floor Area (sq ft)	Pz Population
Analytical Lab	Science laboratories	2010	48
Glass Wash Room	Science laboratories	230	1
Lab Storage	Storage rooms	272	-
Corridor by Lab	Corridors	621	-
Total		**3133**	**49**

AHU-3 (VAV)

Zone	Occupancy Category	Az Floor Area (sq ft)	Pz Population
Reception / Lobby	Reception areas	615	6
Open Office	Office space	3012	22
Office Unit Chief	Office space	140	1
Copy Room	Office space	100	1
Office Storage	Storage rooms	153	-
Classroom Corridor	Corridors	2100	-
Corridor to LAN Room	Corridors	960	-
F.A.T.S.	*(not in scope of Standard 62.1-2004)*	385	4
Laundry Room	Laundry rooms, central	185	1
Clan Lab Equip Corridor	Corridors	1453	-
Clan Lab Equipment	Storage rooms	1470	-
Total		**10573**	**35**

AHU-4 (CV)

Zone	Occupancy Category	Az Floor Area (sq ft)	Pz Population
Raid Facility	*(not in scope of Standard 62.1-2004)*	2000	40
Raid Control Room	Computer (not printing)	260	1
Raid Equipment Room	Storage rooms	200	-
Total		**2460**	**41**

AHU-5 (CV)

Zone	Occupancy Category	Az Floor Area (sq ft)	Pz Population
Smokehouse	*(not in scope of Standard 62.1-2004)*	450	16

AHU-1 (VAV)

Zone	Az Floor Area (sq ft)	Pz Population	Rp (cfm/person)	Rp*Pz (cfm)	Ra (cfm/sqft)	Ra*Az (cfm)	Vbz (cfm)	Ez	Voz (cfm)	Max SA (cfm)	Vpz (cfm)	Vdz (cfm)	Zp	Zd	Evz
Classroom #1	1400	140	7.5	1050	0.06	84	1134	0.8	1417.50	2100	840	840	1.69	1.69	-0.075
Classroom #2	1400	140	7.5	1050	0.06	84	1134	0.8	1417.50	2100	840	840	1.69	1.69	-0.075
Classroom #3 / MPR	565	28	7.5	210	0.06	33.9	243.9	0.8	304.88	660	264	264	1.15	1.15	0.457
Break Room / Pantry	537	16	5	80	0.06	32.22	112.22	0.8	140.28	1600	640	640	0.22	0.22	1.393
Clsrm #1 Equipment	100	-	-	-	0.12	12	12	0.8	15.00	80	32	32	0.47	0.47	1.143
Clsrm #2 Chair Storage	285	-	-	-	0.12	34.2	34.2	0.8	42.75	270	108	108	0.40	0.40	1.216
Conference Room	430	22	5	110	0.06	25.8	135.8	0.8	169.75	520	208	208	0.82	0.82	0.796
Physical Training	465	17	20	340	0.06	27.9	367.9	0.8	459.88	760	304	304	1.51	1.51	0.099
Equipment Try-on	455	17	7.5	127.5	0.06	27.3	154.8	0.8	193.50	370	148	148	1.31	1.31	0.305
Clothing Try-on	400	17	7.5	127.5	0.06	24	151.5	0.8	189.38	380	152	152	1.25	1.25	0.366
Mock Lab	979	17	7.5	127.5	0.06	58.74	186.24	0.8	232.80	900	360	360	0.65	0.65	0.965
Electrical Room	96	-	-	-	0.06	5.76	5.76	1	5.76	1000	400	400	0.01	0.01	1.598
Total	**7112**	**414**		**3222.5**		**449.82**	**3666.56**		**4588.96**	**10740**	**4296**				

Ps	D	Vou (cfm)	Vps (cfm)	max Zp	Xs	Ev	Vot (cfm)
280	0.68	2629.2886	4296	1.688	0.612	-0.075	**-34,840**

AHU-2 (VAV) 100% OA Unit

Zone	Az Floor Area (sq ft)	Pz Population	Rp (cfm/person)	Rp*Pz (cfm)	Ra (cfm/sqft)	Ra*Az (cfm)	Vbz (cfm)	Ez	Voz (cfm)	Max SA (cfm)
Analytical Lab	2010	48	10	480	0.18	361.8	841.8	0.8	1052.25	6015
Glass Wash Room	230	1	10	10	0.18	41.4	51.4	0.8	64.25	480
Lab Storage	272	-	-	-	0.12	32.64	32.64	0.8	40.80	360
Corridor by Lab	621	-	-	-	0.06	37.26	37.26	0.8	46.58	800
Total	**3133**	**49**		**490**		**473.1**	**963.1**		**1203.88**	**7655**

Ps	Vot (cfm)
49	**1,204**

AHU-3 (VAV)

Zone	Az Floor Area (sq ft)	Pz Population	Rp (cfm/person)	Rp*Pz (cfm)	Ra (cfm/sqft)	Ra*Az (cfm)	Vbz (cfm)	Ez	Voz (cfm)	Max SA (cfm)	Vpz (cfm)	Vdz (cfm)	Zp	Zd	Evz
Reception / Lobby	615	6	5	30	0.06	36.9	66.9	0.8	83.63	2300	920	920	0.091	0.091	1.119
Open Office	3012	22	5	110	0.06	180.72	290.72	0.8	363.40	3650	1460	1460	0.249	0.249	0.961
Office Unit Chief	140	1	5	5	0.06	8.4	13.4	0.8	16.75	480	192	192	0.087	0.087	1.122
Copy Room	100	1	5	5	0.06	6	11	0.8	13.75	160	64	64	0.215	0.215	0.995
Office Storage	153	-	-	-	0.12	18.36	18.36	0.8	22.95	60	24	24	0.956	0.956	0.253
Classroom Corridor	2100	-	-	-	0.06	126	126	0.8	157.50	2760	1104	1104	0.143	0.143	1.067
Corridor to LAN Room	960	-	-	-	0.06	57.6	57.6	0.8	72.00	0	0	0	-	-	-
F.A.T.S.	385	4	10	40	0.12	46.2	86.2	0.8	107.75	270	108	108	0.998	0.998	0.212
Laundry Room	185	1	5	5	0.12	22.2	27.2	0.8	34.00	100	40	40	0.850	0.850	0.360
Clan Lab Equip Corridor	1453	-	-	-	0.06	87.18	87.18	0.8	108.98	405	162	162	0.673	0.673	0.537
Clan Lab Equipment	1470	-	-	-	0.12	176.4	176.4	0.8	220.50	740	296	296	0.745	0.745	0.465
Total	**10573**	**35**		**195**		**765.96**	**960.96**		**1201.20**	**10925**	**4370**				

Ps	D	Vou (cfm)	Vps (cfm)	max Zp	Xs	Ev	Vot (cfm)
27	0.771	916.39	4370	0.998	0.210	0.212	**4,322**

AHU-4 (CV)

Zone	Az Floor Area (sq ft)	Pz Population	Rp (cfm/person)	Rp*Pz (cfm)	Ra (cfm/sqft)	Ra*Az (cfm)	Vbz (cfm)	Ez	Voz (cfm)	Max SA (cfm)	Vpz (cfm)	Vdz (cfm)	Zp	Zd	Evz
Raid Facility	2000	40	10	400	0.06	120	520	0.8	650	1800	1800	1800	0.361	0.361	0.921
Raid Control Room	260	1	5	5	0.06	15.6	20.6	0.8	25.75	150	150	150	0.172	0.172	1.111
Raid Equipment Room	200	-	-	-	0.12	24	24	0.8	30	50	50	50	0.600	0.600	0.682
Total	**2460**	**41**		**405**		**159.6**	**564.6**		**705.75**	**2000**	**2000**				

Ps	D	Vou (cfm)	Vps (cfm)	max Zp	Xs	Ev	Vot (cfm)
41	1	564.6	2000	0.6	0.2823	0.6823	**827**

AHU-5 (CV)

Zone	Az Floor Area (sq ft)	Pz Population	Rp (cfm/person)	Rp*Pz (cfm)	Ra (cfm/sqft)	Ra*Az (cfm)	Vbz (cfm)	Ez	Voz (cfm)	Max SA (cfm)
Smokehouse	450	16	20	320	0.06	27	347	0.8	433.75	540

Ps	Vot (cfm)
16	**434**