

Mechanical Technical Report 1

ASHRAE 62.1-2007 Ventilation Compliance Evaluation



Suburban Wellness Center Germantown, Maryland

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October 5, 2007

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Executive Summary

This technical report will provide an analysis on the amount of ventilation air supplied to the Suburban Wellness Center and its compliance with ASHRAE Standard 62.1-2007. Suburban Wellness Center is a 57,200 sq. ft. two story fitness center / medical offices located in Germantown, MD.

Rooftop Unit 1 and Rooftop Unit 2 supply conditioned air to the majority of the building with maximum capacities of 32,000 CFM and 39,000 CFM respectively. The air that comes from RTU-1 and RTU-2 serves the spaces through VAV boxes. Air Handling Unit 1 supplies dehumidified air strictly to the fitness center's swimming pool facility at a rate of 10,500 CFM.

The ventilation rate procedure was applied to the three air conditioning units. If one of the spaces being taken into account didn't fall into an occupancy category, a similar category was chosen or a conservative category was created. While two of them passed, one of the units failed to meet Standard 62.1-2007. RTU-2 failed to meet the standard by 30% however there could be several possibilities as to why this roof top unit did not expel the minimum outdoor air requirement. One of these reasons could be due to different occupancy space categorization which could easily vary based on designer.

	Area (sq. ft.)	Req. OA (cfm)	Supply OA (cfm)	Complies with
RTU-1	12204	3040	4240	Yes
RTU-2	26992	6591	5100	No
AHU-1	4850	2328	7500	Yes
	44046	11960	16840	

Table 1 – Standard 62.1 Compliance Summary

Table 1 summarizes the outdoor air requirements for each of the air conditioners. Listed are the areas each unit serves, the required outdoor air to be supplied, the actual outdoor air being supplied and the compliance verdict of each. The area and supply OA are taken from the construction drawings provided by Meta Engineers PC.

The Suburban Wellness Community Center is a two story 57,200 square foot building which contains a variety of spaces. On the first level is a fitness center and on the second level are conference rooms, offices and private practicing doctor's offices. In the northwest corner of the first floor is the swimming pool area which consists of a large four lane lap pool, a therapy pool, public spa as well as a sauna and steam room. South of this room is the basketball court and racquetball courts which are two stories in height. In the center of the building are the men's and women's lockers rooms and a two story tall atrium with cardiovascular machines and the registration desk. The east side of the first floor holds the free weight rooms in the north and studio spaces for group exercise classes in the south. Figure 1 visually shows the breakdown of each unit coverage.

On the second story (not shown) in the center of the north part of the building are restrooms and conference rooms. The southeast corner of the second story includes an imaging office which can perform X-Rays, MRIs and ultrasounds. The rest of the space on the second floor has yet to be leased out.

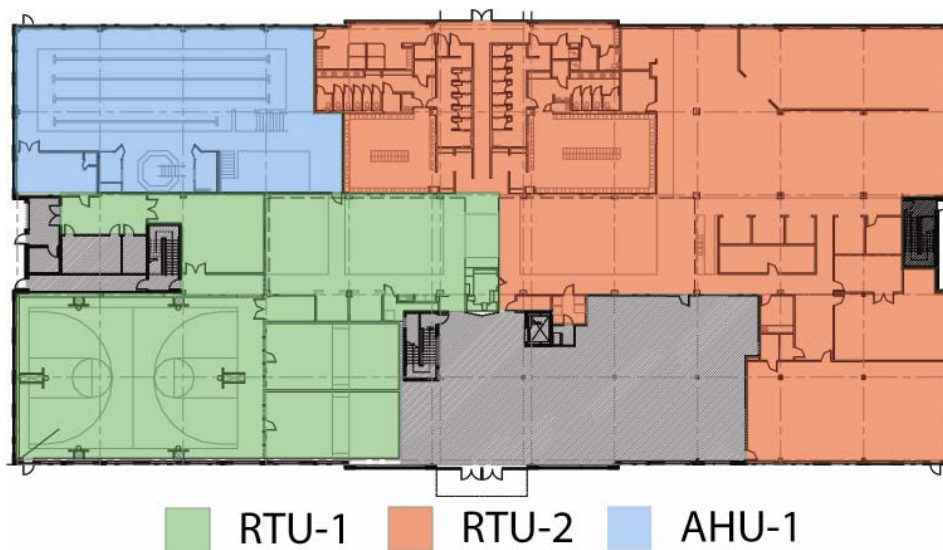


Figure 1 – First Floor Unit Coverage

Mechanical Systems Summary

Two single packaged combination gas-fired heating and electric, air-cooled cooling units provide conditioned air to most of the building. RTU-1 which is located on the west side of the building supplies to the southwest corner while RTU-2 located on the east side of the building supplies to the east half of the building. A separate air handling unit is used to supply conditioned air strictly to the swimming pool facility. RTU-1 supplies to the basketball court, racquetball courts, group cycling room and the cardiovascular machine room. RTU-2 supplies to the locker rooms, weight training area, circuit training area, fitness center offices and group workout studios. Both of these supply to the spaces using a VAV box system with electric reheat which ensures sufficient individual space conditioning control. A variable speed fan drive is also used to give even more control over the conditioning of the supply air.

The northwest corner of the building which holds the swimming pool facility is conditioned by a dehumidification unit. This unit is separate from the two rooftop units and was added at a later point in the design. AHU-1 supplies to the swimming pool facility which has a four lane wide lap pool, public spa and a therapy pool. This space needed a separate unit because of the above average humidity ratio and temperature that must be maintained. Aside from the rooftop units and air handling units, the building also utilizes unit heaters and electric ceiling heaters to heat the stairwells.

Also located near the swimming pool facility is the main mechanical room of the Suburban Wellness Center. Two 800 MBH gas fired water heaters have been placed in the mechanical room to supply hot water throughout the building. To heat the three swimming pools, one 400 MBH and two 250 MBH gas fired pool heaters have been installed. Especially during the winter months when temperatures drop below freezing, these pool heaters take some of the loading off of the dehumidification unit.

Analysis and Assumptions

The ASHRAE Standard 62.1-2007 section 5 was used to carefully design for a number of important issues that could be harmful to the building's system or inhabitants. Some conditions that I took into account were the prevention of the re-entry of contaminated air, prevention of mold growth, particulate filtration and dehumidification systems. Section 5.6.1 stipulates that any outdoor air intakes that are required as part of a natural ventilation system, shall be located such that the shortest distance from the intake to any specific potential outdoor contaminant source shall be equal to or greater than the separation distance listed in Figure 2.

TABLE 5-1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Significantly contaminated exhaust (Note 1)	15 (5)
Noxious or dangerous exhaust (Notes 2 and 3)	30 (10)
Vents, chimneys, and flues from combustion appliances and equipment (Note 4)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 5)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 5)	25 (7.5)
Driveway, street, or parking place (Note 5)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 6 and 7)	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

Figure 2 – ASHRAE Standard 62.1-2007 Table 5-1

When I inspected the roof plan, I measured the distance from the exhaust air goosenecks to the corner of the roof top unit which is where the outside air intake is located. The shortest distance I measured was 34 ft which abides by the 15 ft minimum specified by Section 5.6.1. Prevention of mold growth and particulate filtration are also important aspects in the design and upon looking at the specifications under the mechanical section, measure were taken to control both of these critical issues.

Another condition which could be of particular concern is section 5.10 Dehumidification systems. Section 5.10.1 discusses the need for the relative humidity to be 65% or less which I thought would be an initial problem for my dehumidification system that conditions the supply air to the building swimming pool facility. However, upon reading further, Standard 62.1 notes an exception which includes showers, pools, spas as well as other areas which might need higher humidity conditions.

The ASHRAE Standard 62.1-2007 was used to calculate minimum ventilation rates for breathing zones and design outdoor air requirements. Table 6-1 includes a list of occupancy categories which reports the required minimum outdoor air rates per person and per square foot for those spaces. Since some of the spaces from the Suburban Wellness Center were not able to be categorized with this table, some assumptions were made and are to follow:

- Restrooms: 0.5 cfm/ft²
- Locker Rooms: 0.5 cfm/ft²

Some of the spaces in the building were not very clear to categorize and so when this came up, I took the more conservative approach. Although many of the spaces in the doctor's offices could be categorized as office, I categorized them as medical procedure. The restrooms and locker rooms cfm/ft² is also conservative considering

that the values for a swimming pool are 0.48 cfm/ft². To find the supply air quantity for each space, diffuser flow rates were read off from the mechanical floor plans designed. After these flow rates are summed, they are used to calculate the maximum outdoor air fraction (Zp).

The tables in Appendix A provide crucial space characteristics that were used in the calculation of outside air required. Since all three of the units are important and each have different loads, I decided to analyze all three. Some of the design occupancies were provided by Meta Engineers and those that were not specified were tabulated using Standard 62.1-2007. Outdoor air requirements per person and per square foot were taken from the Standard 62.1-2007 and the supply air quantity was taken from the mechanical floor plans.

Discussion

The results of the ventilation calculations for the Suburban Wellness Center show that RTU-1 and AHU-1 comply with ASHRAE Standard 62.1-2007 however RTU-2 does not. RTU-1 provides approximately 26% more outside air that what is required and AHU-1 supplies approximately 190% more outside air than what is required. While these two units both exceeded the outdoor air that is required, the total outdoor air for all the units did not meet the requirement. The overall system provides 22% below what is necessary according to Std. 62.1 mainly because RTU-2 under supplies outdoor air by 67%. Specific findings may be reviewed in Table 2.

	Area (sq. ft.)	Req. OA (cfm)	Supply OA (cfm)	Vpz (cfm)	Vot (cfm)	Capacity (cfm)	Max Zp	% Above Vot
RTU-1	12204	3040	4240	19335	3378	32000	0.22	25.5%
RTU-2	26992	6591	5100	25510	15858	39000	0.88	-67.8%
AHU-1	4850	2328	7500	10500	2587	10500	0.22	189.9%
	44046	11960	16840	55345	21822	81500		-22.8%

Table 2 – Overall Unit Performance Comparison

Originally when the Suburban Wellness Center was designed, the owners assumed the spaces as offices and had the mechanical systems designed accordingly. When Healthtrax was confirmed to move their fitness center into the first floor, this posed a problem. The Health Club category under the occupancy categories has a more stringent outdoor air requirement than the Office Space category. To counter this, a dehumidification unit was installed to condition the swimming pool facility. Although this addition provided a lot of assistance in the recovery of outdoor air, the building mechanical system is still not up to requirement.

Another major concern and possible reason for discrepancy is the way the Vot was calculated. The maximum Zp that was calculated for RTU-2 was 0.88 which is representing room B160 Men’s Shower located in the men’s locker rooms. Although there is only 200 cfm being supplied, 175 of the 200 cfm should be outdoor air. Since

the amount of exhaust air exceeds the amount of air being supplied, this leads me to believe that the difference is being made up and therefore, conditioned air from other neighboring rooms are being drawn into the room B160. This could be hazardous because it causes pressurization in the spaces and leaves the ventilation airflow unbalanced.

Room #	Room	Az - Area	Function	# Units	Minimum Exhaust Rate		Req. Exhaust Rate	Designed Exhaust Rate	Complies
					Exhaust Rate cfm/unit	Exhaust Rate cfm/sqft			
b144	Toilet Room	68	Restroom	1.00	70		70	75	Yes
b153	Women's Toilet	235	Restroom	6.00	70		420	660	Yes
b159	Men's Toilet	165	Restroom	6.00	70		420	675	Yes
b139	Family Changing	754	Locker Room			0.50	377	450	Yes
b140	Changing Room	28	Locker Room			0.50	14	50	Yes
b142	Changing Room	40	Locker Room			0.50	20	50	Yes
b143	Changing Room	40	Locker Room			0.50	20	75	Yes
b148	Women's Locker Room	680	Locker Room			0.50	340	0	No
b151	Changing Room	30	Locker Room			0.50	15	50	Yes
b152	Changing Room	30	Locker Room			0.50	15	50	Yes
b156	Men's Locker Room	935	Locker Room			0.50	468	0	No
b141	Janitor Closet	12	Storage			1.00	12	75	Yes
b150	Janitor Closet	17	Storage			1.00	17	75	Yes
b158	Janitor Closet	15	Storage			1.00	15	75	Yes

Table 3 – Standard 62.1-2007 Minimum Exhaust Rate

Table 3 reviews calculations I conducted to check the minimum exhaust rates of some of the spaces in the Suburban Wellness Center. All of the restrooms, janitor closets, and changing rooms met these requirements however the locker rooms for both the men and women did not. To much surprise, there weren't any exhaust fans located in the locker rooms. I think one of the possible reasons for this is a change in the standard within recent years. Since the standard that the building complied with dated back to 2001, there is a possibility that locker rooms were not supported.

Supporting Calculations

The procedure is outlined in ASHRAE Standard 62.1-2007 and summarized as follows:

1. The Breathing Zone Outdoor Airflow:

$$V_{bz} = R_p P_z + R_a A_z$$

- R_p = People Outdoor Airflow Rate (Table 6-1)
- R_a = Area Outdoor Airflow Rate (Table 6-1)
- P_z = Zone Population, as designed
- A_z = Zone Floor Area, as designed

2. Determine zone air distribution effectiveness, E_z (Table 6-2)

TABLE 6-2 Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air.	1.0
Ceiling supply of warm air and floor return.	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return.	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level. <i>Note:</i> For lower velocity supply air, $E_z = 0.8$.	1.0
Floor supply of cool air and ceiling return provided that the 150 fpm (0.8 m/s) supply jet reaches 4.5 ft (1.4 m) or more above the floor. <i>Note:</i> Most underfloor air distribution systems comply with this proviso.	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification.	1.2
Floor supply of warm air and floor return.	1.0
Floor supply of warm air and ceiling return.	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return.	0.8
Makeup supply drawn in near to the exhaust and/or return location.	0.5

Figure 3 – ASHRAE Standard 62.1-2007 Table 6-2

3. Determine zone outdoor airflow, V_{oz}

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

4. Determine the primary outdoor air fraction, Z_p

$$Z_p = V_{oz} / V_{pz}$$

- V_{pz} = Zone Primary Airflow, Minimum SA in VAV system

Since Z_p is a ratio of outside airflow divided by primary airflow, the value cannot go over 1. If this value goes over 0.55 another approach, Critical Zone Calculation, must also be calculated.

Critical Zone Calculation

1. Determine uncorrected outdoor air intake, V_{ou}

$$V_{ou} = D \sum_{\text{all zones}} R_p R_z + \sum_{\text{all zones}} R_a A_z$$

- $D = \text{Occupancy Diversity, } D = P_z / \sum_{\text{all zones}} P_z$

2. Determine E_v from Table 6-3

TABLE 6-3 System Ventilation Efficiency

Max (Z_p)	E_v
≤ 0.15	1.0
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
> 0.55	Use Appendix A

Figure 4 – ASHRAE Standard 62.1-2007 Table 6-3

If $Z_p > 0.55$, then use the following equation otherwise skip to step 6.

3. Determine the average outdoor air fraction, X_s

$$X_s = V_{ou} / V_{ps}$$

- $V_{ps} = \text{System Primary Airflow, } \sum V_{pz}$

4. Determine the discharge outdoor air fraction, Z_d

$$Z_d = Z_p \text{ (for VAV Systems)}$$

5. Determine system ventilation efficiency, E_v

$$E_v = 1 + X_s - Z_d$$

6. Determine total outdoor air intake, V_{ot}

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

Nominal Outside Air vs. Required Outside Air

Nominal Outside Air, V_{oz} , which is also referred to as Zone Outdoor Airflow, is the system outdoor airflow that must be provided to the zones by the supply air distribution system. This is found by using V_{bz} , which is found by multiplying the area and population by its corresponding area flow rate and population flow rate. Once added together, V_{bz} is then divided by the zone air distribution effectiveness, E_z .

Required Outside Air, V_{ot} , which is also referred to as Outdoor Air Intake, is a little more complicated and takes into account more variable than Nominal Outside Air. The uncorrected outdoor air intake is the same equation as the breathing zone outdoor airflow except that it takes the sum of all zones for both $R_p P_z$ and $R_z A_z$. Also, an occupant diversity factor is multiplied by $R_p P_z$. This is extremely helpful because the occupant diversity factor takes into account the variations in occupancy within the zones served by the system. Since $D = P_s / \sum_{\text{all zones}} P_z$, when this multiplied by $\sum_{\text{all zones}} R_p P_z$, the P_z cancel out, which leaves V_{ou} taking into account the system population instead of the sum of the zone populations.

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. 2007.

Meta Engineers PC. 2001, Mechanical Construction Documents. Meta Engineers PC, Arlington, VA. 2001.

Appendix A – Space Characteristics

RTU-1

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy
b100	Reception	355	Reception	2
b101	Lounge	472	Break Room	3
b102	Storage	65	Storage	0
b103	Sound Room	50	Telephone / Data Entry	0
b104	Program	75	Office	1
b105	Program	75	Office	1
b106	Storage	115	Storage	1
b107	Hall	300	Corridor	0
b108	Fitness	1338	Health Club / Aerobics	27
b109	Group Cycling	691	Health Club / Aerobics	14
b110	Service Area	305	Storage	1
b111	Hall	170	Corridor	0
b112	Gymnasium	3621	Gym, Stadium	72
b113	Racquetball Court	795	Health Club / Aerobics	4
b114	Racquetball Court	795	Health Club / Aerobics	4
b136	Mechanical Room	350	Electrical Equipment Room	0
b137	Steam Room	77	Swimming	0
b138	Sauna	75	Swimming	0
d100	Waiting	88	Corridor	0
d101	Nurse Station	60	Break Room	2
d102	Reception	63	Reception	2
d103	Toilet (drug testing)	48	Restroom	0
d104	Corridor	54	Corridor	0
d105	Draw Stations	140	Medical Procedure	6
e200	Vestibule	420	Corridor	0
e201	Men's Toilet	160	Restroom	0
e202	Women's Toilet	160	Restroom	0
e203	Misc. Room	118	Storage	0
e204	Conference Room	627	Conference Room	7
e205	Storage	38	Storage	0
e206	Pantry	52	Office	1
e207	Conference Room	425	Conference Room	5
e208	Storage	27	Storage	0
Total		12204		153

RTU-2

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy
b115	Storage	42	Storage	0
b116	Laundry	83	Laundry	1
b117	Hall	320	Corridor	0
b118	Fitness	987	Health Club / Aerobics	20
b119	Sign In	284	Reception	3
b120	Fitness Desk	155	Reception	3
b121	Hall	339	Corridor	0
b122	Fitness Testing	97	Patient Room	1
b123	Intrafit	97	Patient Room	1
b124	Office Suite	275	Office	3
b125	Hall	120	Corridor	0
b126	Marketing	123	Conference Room	2
b127	Office	101	Office	2
b128	Hall	215	Corridor	0
b129	Pilates	223	Health Club / Aerobics	2
b130	Storage	66	Storage	0
b131	Studio B	670	Health Club / Aerobics	14
b132	Warm-up	256	Corridor	0
b132a	Electrical Closet	30	Electrical Equipment Room	0
b133	Staff Room	110	Break Room	2
b133a	Storage	45	Storage	0
b134	Studio A	1801	Health Club / Aerobics	36
b139	Family Changing	754	Locker Room	3
b140	Changing Room	28	Locker Room	1
b141	Janitor Closet	12	Storage	0
b142	Changing Room	40	Locker Room	1
b143	Changing Room	40	Locker Room	1
b144	Toilet Room	68	Restroom	0
b145	Hall	206	Corridor	0
b146	Locker Entry	100	Lobbies	0
b147	Entry	110	Lobbies	0
b148	Women's Locker Room	680	Locker Room	14
b149	Women's Hall	132	Corridor	0
b150	Janitor Closet	17	Storage	0
b151	Changing Room	30	Locker Room	1
b152	Changing Room	30	Locker Room	1
b153	Women's Toilet	235	Restroom	0
b154	Women's Shower	309	Swimming	3
b155	Entry	110	Lobbies	0
b156	Men's Locker Room	935	Locker Room	20

b157	Men's Hall	139	Corridor	0
b158	Janitor Closet	15	Storage	0
b159	Men's Toilet	165	Restroom	0
b160	Men's Shower	365	Swimming	4

RTU-2 Continued

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy
b161	Office	129	Office	2
b162	Meeting Room	129	Conference Room	6
b163	Fitness	800	Health Club / Weight Rooms	18
b164	Free Weights	1445	Health Club / Weight Rooms	13
b165	Fitness	2231	Health Club / Weight Rooms	21
c100	Waiting	92	Corridor	0
c101	Reception	186	Reception	2
c102	Hall	73	Corridor	0
c103	Toilet	48	Restroom	0
c104	Soiled Utility	46	Laundry	0
c105	Copy Room	113	Computer Lab	1
c106	Hydro	80	Medical Procedure	2
c107	Office	150	Office	2
c108	Storage	26	Storage	0
c108a	Electrical	23	Electrical Equipment Room	0
c109	Exam	105	Medical Procedure	2
c110	Rehab Floor	491	Physical Therapy	4
c111	Treatment	48	Medical Procedure	2
c112	Treatment	48	Medical Procedure	2
c113	Treatment	48	Medical Procedure	2
c114	Treatment	48	Medical Procedure	2
c115	Treatment	48	Medical Procedure	2
c116	Treatment	48	Medical Procedure	2
c117	Closet	8	Corridor	0
f200	Waiting	283	Corridor	0
f201	Reception	143	Reception	2
f201a	Anteroom	49	Corridor	0
f202	Staff Room	142	Break Room	2
f203	Toilet	45	Restroom	0
f204	Manager Office	120	Office	2
f205	R&F examination room	300	Medical Procedure	2
f206a	Corridor	175	Corridor	0
f207	Technicians	90	Break Room	2
f208	Radiology Reading	83	Medical Procedure	2
f209	Toilet	56	Restroom	0
f210	Corridor	130	Corridor	0
f211	Files	41	Office	1
f212	Transcript	30	Office	1
f213	S. Linen	46	Office	1
f213a	Corridor	152	Corridor	0

f214	Toilet	49	Restroom	0
f215	Patient Dressing	274	Medical Procedure	1
f215a	Vestibule	48	Corridor	0
f216	Conference Room	62	Conference Room	2

RTU-2 Continued

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy
f217	Telecommunications/Data	45	Telephone / Data Entry	0
f218	X-Ray Room	210	Medical Procedure	2
f219	MRI Computer Room	285	Medical Procedure	2
f220	MRI Examination Room	395	Medical Procedure	2
f221	Control Room	265	Computer (not printing)	2
f222	CT Room	430	Medical Procedure	2
f223	Ultrasound Room	152	Medical Procedure	2
f223a	Corridor	74	Corridor	0
f224	Dexa Examination Room	90	Medical Procedure	1
f225	Corridor	173	Corridor	0
f225a	Corridor	166	Corridor	0
f226	Mammogram Examination Room	133	Medical Procedure	2
f227	Dark Room	48	Photo Studio	2
f228	Storage	33	Storage	0
f228a	Corridor	70	Corridor	0
g100	2nd Floor Corridor	2236	Corridor	0
h100	Pkg A 1st Floor Lobby	893	Lobbies	0
h101	Pkg A Vestibule	165	Corridor	0
h102	Pkg A Party Room	242	Multi-Use Assembly	4
h103	Pkg A Activity Room	1057	Multi-Use Assembly	10
h104	Pkg A Storage	45	Storage	0
h105	Pkg A Toilet	45	Restroom	0
Total		26992		273

AHU-1

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy
b135	Pool	4850	Swimming	0

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Suburban Wellness Center
Germantown, Maryland

Appendix B – Outside Air Requirements

RTU-1

Note Incomplete Mechanical Drawings - in the process of being recovered

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy	OA Requirement									
					Rp - cfm/person	Ra - cfm/ft ²	RpPz	RaAz	Vbz - total	Vpz	Ez	Zp		
b100	Reception	355	Reception	2	5	0.06	10	21.3	31.3	260	31.3	1.00	0.12	
b101	Lounge	472	Break Room	3	5	0.06	15	28.32	43.32	200	43.32	1.00	0.22	
b102	Storage	65	Storage	0	0	0.12	0	7.8	7.8	50	7.8	1.00	0.16	
b103	Sound Room	50	Telephone / Data Entry	0	5	0.06	0	3	3	50	3	1.00	0.06	
b104	Program	75	Office	1	5	0.06	5	4.5	9.5	70	9.5	1.00	0.14	
b105	Program	75	Office	1	5	0.06	5	4.5	9.5	70	9.5	1.00	0.14	
b106	Storage	115	Storage	1	0	0.12	0	13.8	13.8	100	13.8	1.00	0.14	
b107	Hall	300	Corridor	0	0	0.06	0	18	18	140	18	1.00	0.13	
b108	Fitness	1338	Health Club / Aerobics	27	20	0.06	535.2	80.28	615.48	4780	615.48	1.00	0.13	
b109	Group Cycling	691	Health Club / Aerobics	14	20	0.06	276.4	41.46	317.86	1840	317.86	1.00	0.17	
b110	Service Area	305	Storage	1	0	0.12	0	36.6	36.6	865	36.6	1.00	0.04	
b111	Hall	170	Corridor	0	0	0.06	0	10.2	10.2	75	10.2	1.00	0.14	
b112	Gymnasium	3621	Gym, Stadium	72	0	0.3	0	1086.3	1086.3	6200	1086.3	1.00	0.18	
b113	Racquetball Court	795	Health Club / Aerobics	4	20	0.06	80	47.7	127.7	2130	127.7	1.00	0.06	
b114	Racquetball Court	795	Health Club / Aerobics	4	20	0.06	80	47.7	127.7	2130	127.7	1.00	0.06	
b136	Mechanical Room	350	Electrical Equipment Room	0	0	0.06	0	21	21	375	21	1.00	0.06	
b137	Stream Room	77	Swimming	0	0	0.48	0	36.96	36.96	0	36.96	1.00		
b138	Sauna	75	Swimming	0	0	0.48	0	36	36	0	36	1.00		
d100	Waiting	88	Corridor	0	0	0.06	0	5.28	5.28	0	5.28	1.00		
d101	Nurse Station	60	Break Room	2	5	0.06	10	3.6	13.6	0	13.6	1.00		
d102	Reception	63	Reception	2	5	0.06	10	3.78	13.78	0	13.78	1.00		
d103	Toilet (drug testing)	48	Restroom	0	0	0.5	0	24	24	0	24	1.00		
d104	Corridor	54	Corridor	0	0	0.06	0	3.24	3.24	0	3.24	1.00		
d105	Draw Stations	140	Medical Procedure	6	15	0	90	0	90	90	90	1.00		
e200	Vestibule	420	Corridor	0	0	0.06	0	25.2	25.2	0	25.2	1.00		
e201	Men's Toilet	160	Restroom	0	0	0.5	0	80	80	0	80	1.00		
e202	Women's Toilet	160	Restroom	0	0	0.5	0	80	80	0	80	1.00		
e203	Misc. Room	118	Storage	0	0	0.12	0	14.16	14.16	0	14.16	1.00		
e204	Conference Room	627	Conference Room	7	5	0.06	35	37.62	72.62	0	72.62	1.00		
e205	Storage	38	Storage	0	0	0.12	0	4.56	4.56	0	4.56	1.00		
e206	Pantry	52	Office	1	5	0.06	5	3.12	8.12	0	8.12	1.00		
e207	Conference Room	425	Conference Room	5	5	0.06	25	25.5	50.5	0	50.5	1.00		
e208	Storage	27	Storage	0	0	0.12	0	3.24	3.24	0	3.24	1.00		
Total		12204		153			1181.6	1858.72	3040.32	19335	3040.32			
D	1													
You	3040													
Xs	0.157													
Ev	0.941													
Vot	3378													

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy	OA Requirement									
					Rp - cfm/person	Ra - cfm/ft ²	RpZ	RaZ	Vbz - total	Vpz	Voz	Ez	Zp	
b115	Storage	42	Storage	0	0	0.12	0	5.04	0	5.04	0	5.04	1.00	0.10
b116	Laundry	83	Laundry	1	5	0.12	5	9.96	14.96	14.96	150	14.96	1.00	0.12
b117	Hall	320	Corridor	0	0	0.06	0	19.2	19.2	19.2	160	19.2	1.00	0.16
b118	Fitness	987	Health Club / Aerobics	20	20	0.06	394.8	59.22	454.02	454.02	2840	454.02	1.00	0.02
b119	Sign In	284	Reception	3	5	0.06	15	17.04	32.04	32.04	1420	32.04	1.00	0.15
b120	Fitness Desk	155	Reception	3	5	0.06	15	9.3	24.3	24.3	160	24.3	1.00	0.19
b121	Hall	339	Corridor	0	0	0.06	0	20.34	20.34	20.34	105	20.34	1.00	0.20
b122	Fitness Testing	97	Patient Room	1	25	0	25	0	25	25	125	25	1.00	0.09
b123	Intrafit	97	Patient Room	1	25	0	25	0	25	25	125	25	1.00	0.07
b124	Office Suite	275	Office	3	5	0.06	15	16.5	31.5	31.5	350	31.5	1.00	0.17
b125	Hall	120	Corridor	0	0	0.06	0	7.2	7.2	7.2	105	7.2	1.00	0.16
b126	Marketing	123	Conference Room	2	5	0.06	10	7.38	17.38	17.38	100	17.38	1.00	0.06
b127	Office	101	Office	2	5	0.06	10	6.06	16.06	16.06	100	16.06	1.00	0.21
b128	Hall	215	Corridor	0	0	0.06	0	12.9	12.9	12.9	210	12.9	1.00	0.07
b129	Pilates	223	Health Club / Aerobics	2	20	0.06	40	13.38	53.38	53.38	270	53.38	1.00	0.20
b130	Storage	66	Storage	0	0	0.12	0	7.92	7.92	7.92	50	7.92	1.00	0.16
b131	Studio B	670	Health Club / Aerobics	14	20	0.06	280	40.2	320.2	320.2	1540	320.2	1.00	0.07
b132	Warm-up	256	Corridor	0	0	0.06	0	15.36	15.36	15.36	230	15.36	1.00	0.15
b132a	Electrical Closet	30	Electrical Equipment Room	0	0	0.06	0	1.8	1.8	1.8	0	1.8	1.00	0.15
b133	Staff Room	110	Break Room	2	5	0.06	10	6.6	16.6	16.6	110	16.6	1.00	0.11
b133a	Storage	45	Storage	0	0	0.12	0	5.4	5.4	5.4	50	5.4	1.00	0.19
b134	Studio A	1801	Health Club / Aerobics	36	20	0.06	720	108.06	828.06	828.06	4320	828.06	1.00	0.20
b139	Family Changing	754	Locker Room	3	0	0.5	0	377	377	377	1860	377	1.00	0.28
b140	Changing Room	28	Locker Room	1	0	0.5	0	14	14	14	50	14	1.00	0.40
b141	Janitor Closet	12	Storage	0	0	0.12	0	1.44	1.44	1.44	0	1.44	1.00	0.40
b142	Changing Room	40	Locker Room	1	0	0.5	0	20	20	20	50	20	1.00	0.40
b143	Changing Room	40	Locker Room	1	0	0.5	0	20	20	20	50	20	1.00	0.40
b144	Toilet Room	68	Restroom	0	0	0.5	0	34	34	34	0	34	1.00	0.15
b145	Hall	206	Corridor	0	0	0.06	0	12.36	12.36	12.36	80	12.36	1.00	0.06
b146	Locker Entry	100	Lobbies	0	5	0.06	0	6	6	6	100	6	1.00	0.07
b147	Entry	110	Lobbies	0	5	0.06	0	6.6	6.6	6.6	100	6.6	1.00	0.36
b148	Women's Locker Room	680	Locker Room	14	0	0.5	0	340	340	340	940	340	1.00	0.05
b149	Women's Hall	132	Corridor	0	0	0.06	0	7.92	7.92	7.92	160	7.92	1.00	0.05
b150	Janitor Closet	17	Storage	0	0	0.12	0	2.04	2.04	2.04	0	2.04	1.00	0.30
b151	Changing Room	30	Locker Room	1	0	0.5	0	15	15	15	50	15	1.00	0.30
b152	Changing Room	30	Locker Room	1	0	0.5	0	15	15	15	50	15	1.00	0.30
b153	Women's Toilet	235	Restroom	0	0	0.5	0	117.5	117.5	117.5	0	117.5	1.00	0.74
b154	Women's Shower	309	Swimming	3	0	0.48	0	148.32	148.32	148.32	200	148.32	1.00	0.07
b155	Entry	110	Lobbies	0	5	0.06	0	6.6	6.6	6.6	100	6.6	1.00	0.07

RTU-2 Continued

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy	OA Requirement							Vpz	Voz	Ez	Zp
					Rp - cfm/person	Ra - cfm/ft ²	RpPz	RaAz	Vbz - total						
b156	Men's Locker Room	935	Locker Room	20	0	0.5	0	467.5	467.5	1240	467.5	1.00	0.38		
b157	Men's Hall	139	Corridor	0	0	0.06	0	8.34	8.34	0	8.34	1.00			
b158	Janitor Closet	15	Storage	0	0	0.12	0	1.8	1.8	0	1.8	1.00			
b159	Men's Toilet	165	Restroom	0	0	0.5	0	82.5	82.5	110	82.5	1.00	0.75		
b160	Men's Shower	365	Swimming	4	0	0.48	0	175.2	175.2	200	175.2	1.00	0.88		
b161	Office	129	Office	2	5	0.06	10	7.74	17.74		17.74	1.00			
b162	Meeting Room	129	Conference Room	6	5	0.06	30	7.74	37.74	100	37.74	1.00	0.38		
b163	Fitness	800	Health Club / Weight Room	18	20	0.06	360	48	408	1760	408	1.00	0.23		
b164	Free Weights	1445	Health Club / Weight Room	13	20	0.06	260	86.7	346.7	3005	346.7	1.00	0.12		
b165	Fitness	2231	Health Club / Weight Room	21	20	0.06	420	133.86	553.86	2785	553.86	1.00	0.20		
c100	Waiting	92	Corridor	0	0	0.06	0	5.52	5.52		5.52	1.00			
c101	Reception	186	Reception	2	5	0.06	10	11.16	21.16		21.16	1.00			
c102	Hall	73	Corridor	0	0	0.06	0	4.38	4.38		4.38	1.00			
c103	Toilet	48	Restroom	0	0	0.5	0	24	24		24	1.00			
c104	Soiled Utility	46	Laundry	0	5	0.12	0	5.52	5.52		5.52	1.00			
c105	Copy Room	113	Computer Lab	1	10	0.12	10	13.56	23.56		23.56	1.00			
c106	Hydro	80	Medical Procedure	2	15	0	30	0	30		30	1.00			
c107	Office	150	Office	2	5	0.06	10	9	19		19	1.00			
c108	Storage	26	Storage	0	0	0.12	0	3.12	3.12		3.12	1.00			
c108a	Electrical	23	Electrical Equipment Room	0	0	0.06	0	1.38	1.38		1.38	1.00			
c109	Exam	105	Medical Procedure	2	15	0	30	0	30		30	1.00			
c110	Rehab Floor	491	Physical Therapy	4	15	0	60	0	60		60	1.00			
c111	Treatment	48	Medical Procedure	2	15	0	30	0	30		30	1.00			
c112	Treatment	48	Medical Procedure	2	15	0	30	0	30		30	1.00			
c113	Treatment	48	Medical Procedure	2	15	0	30	0	30		30	1.00			
c114	Treatment	48	Medical Procedure	2	15	0	30	0	30		30	1.00			
c115	Treatment	48	Medical Procedure	2	15	0	30	0	30		30	1.00			
c116	Treatment	48	Medical Procedure	2	15	0	30	0	30		30	1.00			
c117	Closet	8	Corridor	0	0	0.06	0	0.48	0.48		0.48	1.00			
f200	Waiting	283	Corridor	0	0	0.06	0	16.98	16.98		16.98	1.00			
f201	Reception	143	Reception	2	5	0.06	10	8.58	18.58		18.58	1.00			
f201a	Anteroom	49	Corridor	0	0	0.06	0	2.94	2.94		2.94	1.00			
f202	Staff Room	142	Break Room	2	5	0.06	10	8.52	18.52		18.52	1.00			
f203	Toilet	45	Restroom	0	0	0.5	0	22.5	22.5		22.5	1.00			
f204	Manager Office	120	Office	2	5	0.06	10	7.2	17.2		17.2	1.00			
f205	R&F examination room	300	Medical Procedure	2	15	0	30	0	30		30	1.00			
f206a	Corridor	175	Corridor	0	0	0.06	0	10.5	10.5		10.5	1.00			
f207	Technicians	90	Break Room	2	5	0.06	10	5.4	15.4		15.4	1.00			
f208	Radiology Reading	83	Medical Procedure	2	15	0	30	0	30		30	1.00			

RTU-2 Continued

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy	OA Requirement						Voz	Ez	Zp
					Rp - cfm/person	Ra - cfm/ft^2	RpPz	RaAz	Vbz - total	Vpz			
f209	Toilet	56	Restroom	0	0	0.5	0	0	28	28	1.00		
f210	Corridor	130	Corridor	0	0	0.06	0	0	7.8	7.8	1.00		
f211	Files	41	Office	1	5	0.06	5	5	2.46	7.46	1.00		
f212	Transcript	30	Office	1	5	0.06	5	5	1.8	6.8	1.00		
f213	S.Linen	46	Office	1	5	0.06	5	5	2.76	7.76	1.00		
f213a	Corridor	152	Corridor	0	0	0.06	0	0	9.12	9.12	1.00		
f214	Toilet	49	Restroom	0	0	0.5	0	0	24.5	24.5	1.00		
f215	Patient Dressing	274	Medical Procedure	1	15	0	15	0	0	15	1.00		
f215a	Vestibule	48	Corridor	0	0	0.06	0	0	2.88	2.88	1.00		
f216	Conference Room	62	Conference Room	2	5	0.06	10	10	3.72	13.72	1.00		
f217	Telecommunications/	45	Telephone / Data Entry	0	5	0.06	0	0	2.7	2.7	1.00		
f218	X-Ray Room	210	Medical Procedure	2	15	0	30	0	0	30	1.00		
f219	MRI Computer Room	285	Medical Procedure	2	15	0	30	0	0	30	1.00		
f220	MRI Examination Roo	395	Medical Procedure	2	15	0	30	0	0	30	1.00		
f221	Control Room	265	Computer (not printing)	2	5	0.06	10	15.9	25.9	25.9	1.00		
f222	CT Room	430	Medical Procedure	2	15	0	30	0	0	30	1.00		
f223	Ultrasound Room	152	Medical Procedure	2	15	0	30	0	0	30	1.00		
f223a	Corridor	74	Corridor	0	0	0.06	0	4.44	4.44	4.44	1.00		
f224	Dexa Examination Ro	90	Medical Procedure	1	15	0	15	0	0	15	1.00		
f225	Corridor	173	Corridor	0	0	0.06	0	10.38	10.38	10.38	1.00		
f225a	Corridor	166	Corridor	0	0	0.06	0	9.96	9.96	9.96	1.00		
f226	Mammogram Examin	133	Medical Procedure	2	15	0	30	0	0	30	1.00		
f227	Dark Room	48	Photo Studio	2	5	0.12	10	5.76	15.76	15.76	1.00		
f228	Storage	33	Storage	0	0	0.12	0	3.96	3.96	3.96	1.00		
f228a	Corridor	70	Corridor	0	0	0.06	0	4.2	4.2	4.2	1.00		
g100	2nd Floor Corridor	2236	Corridor	0	0	0.06	0	134.16	134.16	134.16	1.00		
h100	Pkg A 1st Floor Lobby	893	Lobbies	0	5	0.06	0	53.58	53.58	53.58	1.00		
h101	Pkg A Vestibule	165	Corridor	0	0	0.06	0	9.9	9.9	9.9	1.00		
h102	Pkg A Party Room	242	Multi-Use Assembly	4	7.5	0.06	30	14.52	44.52	44.52	1.00		
h103	Pkg A Activity Room	1057	Multi-Use Assembly	10	7.5	0.06	75	63.42	138.42	138.42	1.00		
h104	Pkg A Storage	45	Storage	0	0	0.12	0	5.4	5.4	5.4	1.00		
h105	Pkg A Toilet	45	Restroom	0	0	0.5	0	22.5	22.5	22.5	1.00		
Total		26992		273			2644.8	2552.02	6591.38	25510	6591.38		
D		1											
Vou		5197											
Xs		0.204											
Ev		0.328											
Vot		15858											

AHU-1

Room #	Room	Az - Area (sq.ft.)	Function	Design Occupancy	OA Requirement								
					Rp - cfm/person	Ra - cfm/ft ²	RpPz	RaAz	Vbz - total	Vpz	Voz	Ez	Zp
b135	Pool	4850	Swimming	0	0	0.48	0	2328	2328	10500	2328	1.00	0.22
D		1											
Vous		2328											
Xs		0.222											
Ev		1.000											
Vot		2587											

Cory J. Abramowicz
 Mechanical Option
 Faculty Advisor: Dr. Jim Freihaut

Suburban Wellness Center
 Germantown, Maryland

Appendix C – Maximum Zp

	Area (sq. ft.)	Req. OA (cfm)	Supply OA (cfm)	Vpz (cfm)	Vot (cfm)	Capacity (cfm)	Max Zp	% Above Vot
RTU-1	12204	3040	4240	19335	3378	32000	0.22	25.5%
RTU-2	26992	6591	5100	25510	15858	39000	0.88	-67.8%
AHU-1	4850	2328	7500	10500	2587	10500	0.22	189.9%
	44046	11960	16840	55345	21822	81500		-22.8%