TECHNICAL REPORT I

ASHRAE STANDARDS 62.1 AND 90.1 COMPLIANCE EVALUATION

8/29/08

WEST VIRGINIA UNIVERSITY ALUMNI CENTER

Morgantown, West Virginia

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MECHANICAL OPTION

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Executive Summary

The West Virginia University Alumni Center is a newly constructed, 48,000 ft² multi-use building. The Alumni Center is comprised of a 3-story main building and a single story, double height banquet hall. The main building consists of a commercial kitchen, 6 meeting rooms, a board room, bar/lounge, staff offices, and open office space. The banquet hall is a 7,000 ft² space that can be subdivided into 3 reception halls by using retractable walls.

ASHRAE Standard 90.1-2007 provides minimum requirements for energy efficiency in buildings. The building envelope, heating, ventilating and air conditioning systems, service water heating system, and power and lighting systems were checked for compliance with Standard 90.1-2007. The building was found to be compliant with all relevant sections of the Standard as summarized in Table 1.

Table 1 – ASHRAE Standard 90.1-2007 Compliance Summary

	Required by Std 90.1	Building Envelope Compliance
Roof Insulation	R-20	Yes
Wall Insulation	R-13	Yes
Glass U-Value	0.35	Yes
Glass SHGC	0.4	Yes

	Required by Std 90.1	HVAC Systems
Gas Furnaces	E_t=80%	Yes
Air Cooled Air Conditioners	9.5 or 9.3 EER	Yes
Split System Air Conditioners	13 SEER	Yes
Pipe Insulation	Varies	Yes
Service Water Heating	E_t=80%	Yes

	Required by Std 90.1	Power Lighting
Voltage Drop	2% and 3%	Yes
Lighting Power Density	1.2 W/sq. ft	Yes

The outdoor ventilation rates for the Alumni Center were determined using the ASHRAE Standard 62.1-2007 Ventilation Rate Procedure. Compliance with the requirements of Section 6 of Standard 62.1 was checked for 3 Air Handling units. Air Handling Units 1, 2, and 4 were chosen for analysis as they include a variety of occupancy categories and should closely resemble the compliance of all other air handling units.

AHU-1 and AHU-2 both serve the main building of the Alumni Center and have direct expansion cooling with gas furnace heating. The AHU's distribute air to variable air volume terminal devices with electric reheat coils at each zone. AHU-4 is a constant air volume unit that serves 1/3 of the Banquet Hall with direct expansion cooling

and gas furnace heating. Table 2 summarizes the Alumni Center's compliance with Standard 62.1. AHU-1 and AHU-2 did not meet the requirements of the standard while AHU-4 did.

Table 2 – ASHRAE Standard 62.1-2007 Ventilation Rate Compliance Summary

	Calculated OA (cfm)	Design Supply Air Flow (cfm)	Design Minimum OA (cfm)	ASHRAE 62.1 Compliance
AHU-1	2980	8690	2173	No
AHU-2	5969	15215	5325	No
AHU-4	5000	1218	2500	Yes

The Alumni Center was also checked for compliance with Section 5 of Standard 62.1 which provides requirements on maintaining acceptable indoor air quality. All relevant requirements of Section 5 were met and the Alumni Center is compliant.

ASHRAE Standard 90.1 Compliance

ASHRAE Standard 90.1 provides minimum requirements for energy efficiency in buildings. Analysis of the Alumni Center's compliance to Standard 90.1 is divided into Building Envelope; Heating, Ventilating and Air Conditioning; Service Water Heating; Power and Lighting. A summary of the Alumni Center's compliance with Standard 90.1 is outlined below.

Building Envelope

Section 5 of ASHRAE Standard 90.1 provides minimum requirements for the building envelope. To determine the requirements for the building envelope that the Alumni Center must follow, the Climate Zone must be determined. Morgantown, WV is in Monongalia County, which is part of Climate Zone 5A as defined in Table B-1 of Standard 90.1

The Alumni Center has a vertical fenestration area that is less than 40% of the gross wall area and skylight fenestration that is less than 5% of the gross roof area as shown in Table 1. With these requirements met, the building can follow the Prescriptive Building Envelope Compliance Path.

Table 3 – Window Area Summary

	Gross Area	Window Area	Window %
Walls	22575	4603.1	20.4%
Roof	15814	0	0.0%

Construction of the building envelope was compared to Table 5.5-5 of Standard 90.1, which provides the requirements for building envelope compliance for nonresidential buildings in Climate Zone 5A. The details of the building envelope are included below and Table 2 summarizes the Alumni Center's compliance with the Building Envelope requirements outlined in Table 5.5-5 of the standard.

- Roof Construction – 20 gage steel roof deck with tapered rigid insulation with an average R-Value of 30
- Exterior Wall Construction – 4" face brick, 2" R-14 rigid insulation, ½" sheathing and 6" steel studs
- Glazing – double paned and argon filled with Low-E coating for a maximum U-value of 0.35, Shading Coefficient of 0.48, Solar Heat Gain Coefficient (SHGC) of 0.37 and a Visible Light Transmittance of 73%

Table 4 – ASHRAE Standard 90.1 Building Envelope Compliance Summary

	Min Roof Insulation R-Value	Wall Insulation Minimum R-Value	Non-Heated Slab on Grade Floors	Fenestration Max U-Value	Fenestration Max SHGC
Required Value	R-20	R-13	N/A	0.35	0.4
Designed Value	R-30	R-14	N/A	0.35	0.37
Compliance	Yes	Yes	N/A	Yes	Yes

The R-value of the roof insulation is significantly higher than required by Standard 90.1. The R-value for wall insulation, fenestration U-value and fenestration SHGC are all slightly better than required by the standard. The Alumni Center meets all of the requirements to have a compliant building envelope under ASHRAE Standard 90.1.

Heating, Ventilating and Air Conditioning

Section 6 of Standard 90.1 defines energy efficiency requirements for the mechanical equipment that provides heating, cooling and ventilation to new buildings and designates the appropriate thickness of insulation for plumbing and mechanical piping. There are two compliance paths for Section 6. The Alumni Center will follow the Mandatory Provisions Method for compliance, as it does not meet the qualifications to follow the Simplified Approach Option. The requirements for the Mandatory Provisions Method are outlined in Section 6.4 of the standard.

Mechanical Equipment

Tables 3, 4 and 5 summarize the Alumni Center's compliance with the minimum equipment efficiencies, EER's and SEER's outlined in Tables 6.8.1 A-J of the Standard. All equipment in the building meet the minimum requirements, therefore the building complies with this section of Standard 90.1.

Table 5 – ASHRAE Standard 90.1 Gas Furnace Efficiency Compliance

	AHU-1	AHU-2	AHU-3	AHU-4	AHU-5	AHU-6	AHU-7	AHU-8	AHU-9
Efficiency As Designed	81	81	81	81	81	81	81	81	81
Required Efficiency	80	80	80	80	80	80	80	80	80
Compliance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6 – ASHRAE Standard 90.1 Air Cooled Air Conditioner EER Compliance

	AHU-1	AHU-2	AHU-3	AHU-4	AHU-5	AHU-6	AHU-7	AHU-8	AHU-9
EER As Designed	9.3	9.3	9.5	9.5	9.5	9.5	9.3	N/A	9.3
Required EER	9.5	12.3	10.6	11.5	11.5	11.5	10.4	N/A	13
Compliance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7 – ASHRAE Standard 90.1 Split System Air Conditioner SEER Compliance

	SSAHU-1	SSAHU-2	SSAHU-3
SEER As Designed	13	13	13
Required SEER	13	13	13
Compliance	Yes	Yes	Yes

Pipe Insulation Thickness

Table 6 summarizes the buildings compliance with the minimum pipe insulation thickness required by Table 6.8.3 of Standard 90.1. All of the insulation specified for the building meets the requirements to be compliant with this section of the standard.

Table 8 – ASHRAE Standard 90.1 Pipe Insulation Thickness Compliance

	Domestic Hot Water Systems 105+° Operating Temp Nominal Pipe Size			Cooling Systems 40-60° Operating Temp Nominal Pipe Size	
	<1"	1 to < 1-1/2"	1-1/2" to <4"	<1"	1 to < 1-1/2"
	Insulation Thickness			Insulation Thickness	
Required	0.5	0.5	1	0.5	0.5
As Designed	0.5	0.5	1	0.75	0.75
Compliance	Yes	Yes	Yes	Yes	Yes

Service Water Heating

Section 7 of ASHRAE Standard 90.1 defines the minimum performance required for water heating equipment. The Alumni Center utilizes two gas-fired water heaters that require a minimum thermal efficiency of 80% as per Standard 90.1. Both water heaters are rated at 85% efficiency, which complies with the requirements of this section of the standard.

Power/Lighting

Power

Section 8 of ASHRAE Standard 90.1 defines the maximum voltage drop for both feeders and branch circuits. Feeders must be sized for a maximum voltage drop of 2% at design load and branch circuits must be sized for a maximum voltage drop of 3% at design load. The electrical designer designed the electrical system to comply with Standard 90.1 and therefore sized the feeders and branch circuits to comply with the maximum voltage drop dictated in the standard.

Lighting

Section 9 of Standard 90.1 provides requirements for the lighting power density. There are two compliance paths for this section. The first compliance path is the Building Area Method, which requires the entire building's lighting power density to be below a certain level for a specified building type. If the building fails to comply using the Building Area Method the Space by Space method can be used. For the Alumni Center the Building Area Method was applied for compliance with the building classified as a School/University building. Table 7 summarizes the Alumni Center's compliance with Section 9 of the standard.

Table 9 – ASHRAE Standard 90.1 Lighting Power Density Compliance

Floor	Area (sq. ft.)	Lighting Power (Watts)	Lighting Density (W/sq. ft.)
Ground	27000	25093	0.93
First	10500	11383	1.08
Second	10500	11750	1.12
Total	**48000**	**48226**	**1.00**

ASHRAE Std. 90.1 Max Lighting Density	1.2
Compliance	Yes

Table 7 shows that the Alumni Center has a lighting power density that is less than the maximum allowable for a School/University Building. If the building would be classified as an Office Building, which is its primary function after being a University Building, it would still meet the requirements for compliance as the maximum allowable lighting power density for an office building is 1.0 W/sq. ft. The Alumni Center meets the requirements for compliance with Section 9 of Standard 90.1.

ASHRAE Standard 62.1 Section 5 Compliance

Section 5 of ASHRAE Standard 62.1 provides requirements to maintain acceptable indoor air quality. A summary of the Alumni Center's compliance with Section 5 is outlined below.

Section 5.1-Natural Ventilation

There are no engineered natural ventilation systems in the Alumni Center therefore section 5.1 does not apply

Section 5.2-Ventilation Air Distribution

The Variable Air Volume system designed for this building can be adjusted to meet the minimum ventilation air flow as calculated from Section 6 of ASHRAE Standard 62.1. An analysis of the building's compliance with Section 6 is included in this report.

Section 5.3-Exhaust Duct Location

All exhaust ducts are sealed in accordance with SMACNA Seal Class A as described in *HVAC Duct Construction Standards, Metal and Flexible, 2nd Edition (1995)* and therefore are exempt from being negatively pressurized relative to the spaces through which they pass. While meeting the criteria to be exempt from this requirement, all exhaust ducts have been specified to be negatively pressurized. As such, the project meets the requirements of Section 5.3.

Section 5.4-Ventilation System Controls

The building has been designed to be controlled by a Direct Digital Control (DDC) system. The DDC system controls all thermostats and dampers/operators and allow the system to maintain the minimum outdoor airflow as determined by the procedure in Section 6 of Standard 62.1. An analysis of the building's compliance with Section 6 is included in this report. The DDC system allows the project to meet the requirements of Section 5.4.

Section 5.5-Airstream Surfaces

Section 15815 Part 2.3 of the project specifications state that Air Handling Units 2 and 3 shall be installed with duct liner. The duct liner is specified to "be coated with an approved surface covering to prevent erosion of glass fibers…and shall be impregnated with an EPA-Registered biocide to inhibit mold and bacteria growth. Insulation shall be treated with biocide to inhibit biological growth." With this specification the project meets the requirements of Section 5.5.

Section 5.6-Outdoor Air Intake

The 9 air handling units are all located on the various levels of roofs of the Alumni Center. Section 5.6 of Standard 62.1 specifies the minimum distance the outdoor air intake for each of these air handlers can be from specific contaminant sources. All requirements for separation distance are met for all of the air handlers including AHU-8, which is a make-up air unit for the kitchen space. The minimum separation distance for significantly contaminated exhaust (the kitchen exhaust may have an offensive odor as described in Note 1 of

Section 5.6) is 15 ft and the nearest kitchen exhaust fan is 18 ft away. This distance meets the stipulations of Section 5.6 but the separation could be greater.

All rooftop AHU's are equipped with bird screens and rain lips at both the outside air section and exhaust air section in compliance with Section 5.6.

Section 5.7-Local Capture of Contaminants

There are no contaminants produced from non-combustion equipment, therefore this section does not apply to the project.

Section 5.8-Combustion Air

The gas furnaces in the air handling units and the emergency gas generator all equipped with sufficient air for combustion and vented directly outdoors in compliance with Section 5.8.

Section 5.9-Particulate Matter Removal

Filters for all AHU's are located upstream of all cooling coils and are specified to be 30% efficient. A 30% efficient filter equates to a Minimum Efficiency Reporting Value (MERV) of approximately 7, which exceeds the requirements of Section 5.9.

Section 5.10-Dehumidification Systems

The Alumni Center does not have any systems designed to provide dehumidification beyond the dehumidification that occurs when the air is heated in the AHU's. All spaces in the building are designed to maintain a relative humidity (RH) of less than 65% except for the Kitchen, which may rise above 65% RH. Under this section kitchens are allowed to exceed 65% RH, therefore the building meets the requirements of Section 5.10.

Section 5.11-Drain Pans

All AHU's are specified to include an insulated, stainless steel drain pan beneath the cooling coil that extends to a PVC drain pipe with a p-trap and terminates over a 4" concrete splash block. With this drain pan the requirements of Section 5.11 are met.

Section 5.12-Finnned-Tube Coils and Heat Exchangers

All AHU's with cooling coils include 24" of access space, greater than the 18" of access space required by Section 5.12.

Section 5.13-Humidifiers and Water-Spray Systems

There are no humidifiers or water-spray systems for this project; therefore this section does not apply.

Section 5.14-Access for Inspection, Cleaning and Maintenance

All ventilation equipment is provided with adequate clearance for inspection and routine maintenance. All AHU's and Variable Volume boxes are provided with access doors that are adequately sized to allow unobstructed access to the equipment.

Section 5.15-Building Envelope and Interior Surfaces

The exterior façade of the building is brick that is slightly permeable. To stop additional moisture penetration there is a properly placed air gap and modified bituminous vapor barrier with weep holes placed at 24" on center in compliance with Section 5.15.

All domestic cold water piping is insulated with ½" mineral fiber insulation to prevent the formation of condensation on the pipe or anywhere within the insulation to meet the requirements of Section 5.15.

Section 5.16-Buildings with Attached Parking Garages

There are no attached parking garages for this project; therefore this section does not apply.

Section 5.17-Air Classification and Recirculation

All of the return air in the building is designated as Class 1 (low contaminate concentration) and may be recirculated or transferred to any space in the building. Air from the kitchen is designated as either Class 4 or Class 3 and is exhausted directly to the outdoors. All requirements of Section 5.17 are met.

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

The West Virginia University Alumni Center is a non-smoking facility and is therefore entirely ETS-Free. As an ETS-Free building Section 5.18 does not apply to this project.

ASHRAE Standard 62.1 Section 6 – Ventilation Rate Calculation Procedure

Section 6 of ASHRAE Standard 62.1 outlines the Ventilation Rate Procedure, which is a prescriptive procedure to determining the minimum outdoor air intake rates based on the amount of occupants, floor area, space type and other factors. The Ventilation Rate Procedure uses specific methods and formulas, which are detailed in Section 6 of Standard 62.1 and were utilized for the calculation of minimum outdoor air flow for the Alumni Center.

ASHRAE Standard 62.1 Section 6 – Calculation Assumptions

Spaces Calculated

Ventilation rates were not calculated for every space in the building. Spaces served from AHU-1, AHU-2, and AHU-4 were calculated and included a variety of different occupancy categories. AHU-1 serves lobbies, office space, an expansion, pre-event lounge, and storage rooms. AHU-2 serves lounges, conference rooms, museum/gallery spaces, and office spaces. AHU-3 serves 1/3 of the Banquet Hall. These calculations include all occupancy categories for the building and should closely represent the compliance of the entire building.

Occupancy Category

Section 6 of Standard 62.1 provides the minimum ventilation rates based on occupancy category. Since all occupancy categories cannot be included in the standard, some assumptions were made to match the actual intended use of the spaces in the Alumni Center with the Occupancy Categories listed in Section 6. The notable assumptions are:

- Room 004A on the ground floor is labeled as Expansion on the architectural floor plans. The function of this space has not been defined but since it is close to both the lobby and banquet hall it has been classified as Lobby/Pre-function.
- Room 002 on the ground floor is titled the Hall of Honor. This space most likely includes historical information as well as images and other memorabilia celebrating alumnus of West Virginia University. As such, this room was classified as Museum/Galleries.
- Room 206 on the second level is titled Food Prep and Serve. This space is not a kitchen; it is merely a location to organized food coming from the kitchen before it is served. The closest match to this use is Cafeteria/Fast Food Dining.

Zone Population

Zone populations were calculated using Table 6-1 of Standard 62.1 or, in some cases, were specified by the architect.

Supply Air Flow Rates

Supply air flow rates for all zones were taken from the mechanical schedules, which listed both the maximum and minimum flow rates to each variable volume box for AHU-1 and AHU-2 and the constant volume design air flow rate for AHU-4.

Diversity

Without knowing more information about the usage schedule of the building an accurate diversity factor cannot be determined. With this in mind, a conservative estimate of Diversity=1.0 was used for all calculations using a diversity factor.

ASHRAE Standard 62.1 Section 6 – Discussion of Results

The Ventilation Rate Procedure of ASHRAE Standard 62.1 was followed to calculate the required flow rate of outdoor air for each of three air handlers. The calculation results are summarized in Table 1. For full calculation tables refer to Appendices 1, 2, and 3.

Table 10 – Ventilation Rate Compliance Summary

	Calculated OA (cfm)	Design Supply Air Flow (cfm)	Design Minimum OA (cfm)	ASHRAE 62.1 Compliance
AHU 1	2980	8690	2173	No
AHU-2	5969	15215	5325	No
AHU-4	5000	1218	2500	Yes

AHU-1

Air Handling Unit 1 does not comply with ASHRAE Standard 62.1 Section 6 as calculated for this report. The reason that this AHU does not comply is that the Zone Primary Air Fraction (Z_p) for the Lobby is very high. The Lobby was the critical space for this AHU and had a Z_p above 0.55. As a result, the Zone Ventilation Efficiency (E_{vz}) for that space was calculated using Appendix A of Section 6. The E_{vz} was calculated to be 0.41 and as a result, the required flow rate of outdoor air for AHU-1 was determined to be above the flow rate of outdoor air that is actually being supplied.

The reason that the Z_p for the Lobby was so high was because of the assumed population for that space. The Zone Population (P_z) for the Lobby was calculated using Table 6-1 of Standard 62.1. The resulting population for the zone was 60 people, which is larger than the amount of people that will likely occupy that space. The designer of the system may have had more information about the expected number of occupants for this zone and therefore could more accurately calculate the required outdoor air flow. If the population for this space is reduced from 60 people to 44 people, a small decrease, the AHU would have complied with the standard.

An additional assumption that may have changed the results of the calculations was the assumption that Diversity (D) = 1. If more information was known about the occupancy schedule of the spaces served by AHU-1 an accurate Diversity factor could have been determined. If the diversity factor for AHU-1 was determined to be 0.75, the requirements of Section 6 would have been met for AHU-1. A diversity factor of 0.75 would most likely not be meet for these spaces but it is important to note that a change in the diversity could affect the compliance of this AHU.

AHU-2

Air Handling Unit 2 does not comply with ASHRAE Standard 62.1 Section 6 as calculated for this report. The calculated results for AHU-2 were very similar to the calculated results for AHU-1. The same assumptions that could have changed the results for AHU-1 could have also changed the results for AHU-2.

For AHU-2 the Lounge was the most critical space with a Z_p of 0.78. Again, with such a high Z_p the E_{vz} must be calculated using Appendix A of Section 6. The E_{vz} for this space was calculated to be 0.37 and as a result, the

required flow rate of outdoor air for AHU-2 was determined to be above the flow rate of outdoor air that is actually being supplied. If the population of this space is reduced from 12 people to 10 people the AHU would have complied with the standard.

Additionally, a change in the diversity may also change the compliance of AHU-2. If the diversity is changed from 1.0 to 0.89 the AHU would have complied with the standard. Because AHU-2 serves mostly conference rooms and gathering spaces it is fully possible that the diversity could be reduced to 0.89 for this AHU and the AHU could comply with the standard.

AHU-4

Air Handling Unit 4 complies with ASHRAE Standard 62.1 Section 6 as calculated for this report. AHU-4 serves 1/3 of the Banquet Hall and is therefore representative of the other two AHU's serving that space and it can be assumed that since AHU-4 complies with Section 6 that AHU-5 and AHU-6 also comply with the standard.

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.

ASHRAE. 2007, ANSI/ASHRAE, Standard 90.1-2007, Energy Standard for Building Except Low-Rise Residential Buildings. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

H.F. Lenz Company. 2003-2008. Mechanical Construction Documents. H.F. Lenz Company, Johnstown, PA.

IKM Inc. 2007. Architectural Construction Documents. IKM Inc., Pittsburgh, PA.

Appendix 1 – AHU 1 Ventilation Calculations

AHU-1 Ventilation Calculations													
Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Vpzm	Zp	Evz
003	Lobby	Lobbies	397	60	5	0.06	300	23.82	324	1540	441	0.73	0.41
004a	Expansion	Lobbies/Prefunction	1215	37	7.5	0.06	277.5	72.9	350	3000	950	0.37	
004b	Storage	Storage Rooms	715	0	0	0.12	0	85.8	86	860	325	0.26	
004c	Office	Office Space	190	1	5	0.05	5	9.5	15	140	49	0.30	
005	Coats	Storage Rooms	235	0	0	0.12	0	28.2	28	150	150	0.19	
011	Pre-Event Lounge	Lobbies/Prefunction	1360	41	7.5	0.06	307.5	81.6	389	3000	950	0.41	

Vou=∑Voz	1192
Vps=∑Vpz	8690
Xs=(Vou/Vps)	0.14
Ev=min(Evz)	0.4
Vot=Vou/Ev	2980

Appendix 2 – AHU-2 Ventilation Calculations

AHU-2 Ventilation Calculations													
Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Vpzm	Zp	Evz
002	Hall of Honor	Musuem/Galleries	300	12	7.5	0.06	90	18	108	1400	490	0.22	
003	Lobby	Lobbies/Prefunction	783	23	7.5	0.06	172.5	46.98	219	1000	325	0.68	0.47
101	Corridor	Corridors	1020	0	0	0.06	0	61.2	61	600	210	0.29	
102	Club Room	Musuem/Galleries	1350	54	7.5	0.06	405	81	486	2350	823	0.59	0.56
103	Bar	Bars, Cocktail Lounges	115	1	7.5	0.18	7.5	20.7	28	100	100	0.28	
104	Lounge	Bars, Cocktail Lounges	263	12	7.5	0.18	90	47.34	137	500	175	0.78	0.37
105	Storage	Storage Rooms	127	0	0	0.12	0	15.24	15	350	122	0.12	
106	Privacy Room	Office Space	190	4	5	0.06	20	11.4	31	215	145	0.22	
109	Corridor	Corridors	115	0	0	0.06	0	6.9	7	200	70	0.10	
110	Meeting 1	Conference/Meeting	725	24	5	0.06	120	43.5	164	1000	325	0.50	
111	Meeting 2	Conference/Meeting	725	24	5	0.06	120	43.5	164	1000	325	0.50	
112	Meeting 4	Conference/Meeting	335	12	5	0.06	60	20.1	80	650	230	0.35	
114	Corridor	Corridors	1028	0	0	0.06	0	61.68	62	850	298	0.21	
115	Meeting 3	Conference/Meeting	685	24	5	0.06	120	41.1	161	1200	420	0.38	
116	Storage	Storage Rooms	267	0	0	0.12	0	32.04	32	100	100	0.32	
201	Governors Suite	Conference/Meeting	429	8	5	0.06	40	25.74	66	800	280	0.23	
203	Board Room	Conference/Meeting	1245	28	5	0.06	140	74.7	215	1700	590	0.36	
206	Food Prep/Serve	Cafeteria/Fast Food Dining	421	2	7.5	0.18	15	75.78	91	550	190	0.48	
226	Meeting	Conference/Meeting	361	12	5	0.06	60	21.66	82	650	230	0.36	

Vou=∑Voz	2209
Vps=∑Vpz	15215
Xs=(Vou/Vps)	0.15
Ev=min(Evz)	0.37
Vot=Vou/Ev	5969

Appendix 3 – AHU-4 Ventilation Calculations

AHU-4 Ventilation Calculations											
Room Number	Room Name	Occupancy Category	Az	Pz	Rp	Ra	Pz*Rp	Az*Ra	Voz	Vpz	Vpzm
030A	Banquet Hall	Multipurpose Assembly	2420	143	7.5	0.06	1072.5	145.2	1218	5000	5000

Voz	1218
Vot=Voz	1218