Technical Assignment #1

ASHRAE Standard 62.1-2004 Ventilation Compliance Evaluation Report

The Gateway at MICA
Baltimore, MD

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Mechanical Option

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Table of Contents

Executive Summary

The purpose of this report is to evaluate The Gateway at MICA located in Baltimore, MD for it's compliance with ASHRAE standard 62.1-2004 minimum ventilation rates. From standard 62.1 the Ventilation Rate Procedure was used to obtain the results contained within this report.

The Gateway at MICA is a 120,000 ft^2 building used primarily for student housing. It contains nine stories with a 10^{th} story mechanical penthouse and a third floor mechanical room.

There are four air-handling units (AHU) in the building that service multiple zones, the supply air delivered by these AHUs range from 9,600 cfm to 14,500 cfm. The outside air ranges from 2,900 cfm to 7,000 cfm. A comprehensive summary of the mechanical system is included in page three to provide in-depth information about the air side system of The Gateway at MICA.

From the calculations, all AHUs at The Gateway at MICA comply with ASHRAE standard 62.1-2004. The calculations show that all the units have a minimum outdoor air intake that exceeds the calculated required airflow according to the ASHRAE standard based on an assumed ventilation effectiveness of 1.0.

Mechanical Air-Side System Summary

The air-side system of The Gateway at MICA consists of four, 100% outdoor air economizing, draw thru AHUs. Three of the AHUs are located in the third floor mechanical room while the fourth is in the 10^{th} level penthouse. The three units in the mechanical room service spaces on the first two levels of the building, while the penthouse unit serves the studio space on each floor of the student living level.

AHU-1 serves the public spaces and rooms on level one and two including some parts of the lobby, the café, conference rooms, offices, and other various spaces throughout levels one and two. This unit has a supply max of 14,500 cfm and supply min of 6,000 cfm. The outside air max and min are 14,500 cfm and 2,900 cfm respectively.

AHU-2 serves the multi-purpose performance space including the booth as well as the facilities office. AHU-2 has a supply maximum and minimum of 9,600 cfm and 4,000 cfm respectively. The multi-purpose space is roughly 3,100 ft^2 and located in the center of the building plan. This space is a double height space with a monitoring booth at one of the room on the second level which is also serviced by AHU-2.

AHU-3 provides air for the lobby/pre-function space and the gallery as well. This is the only constant volume AHU in The Gateway at MICA. The gallery is a single height space just inside the main entrance of the building. This space opens to the lobby/pre-function space which is a double height space. The total floor area for these spaces is roughly 3,600 ft^2. The supply maximum and minimum of AHU-3 is 12,000 cfm and 5,000 cfm respectively. The outdoor air maximum is 12,000 cfm and the minimum is 3,200 cfm.

AHU-4 serves the studio spaces on level three through nine. These seven spaces each have an area of 848 ft^2 and are provided for the students to do work without having to leave their living quarters. The maximum supply and outdoor air for this unit is 11,600 cfm while the minimum supply and outdoor air is 7,000 cfm.

All spaces supplied by AHU-1, AHU-2, and AHU-3 are have terminal units equipped with water-side reheat coils to condition the air as per the requirements of that spaces occupants.

All other spaces on levels three through nine have a water-side fan coil unit system and do not contain any air-side components. These spaces were not taken into consideration for this report.

Assumptions

In doing the calculations for the Ventilation Rate Procedure a few assumptions had to be made. All adjustments and assumptions are described in this section.

To obtain the supply air quantities for the spaces, the supply air listed for the Terminal Units in the schedule were used. When these numbers were added there was a discrepancy with AHU-1. The value obtained from the added numbers was used for this report.

Spaces not containing diffusers on the first two levels were not taking into consideration for this report. These spaces include, but are not limited to, stairwells, elevators, corridors, restrooms, etc. It was assumed that these spaces would be adequately ventilated by transfer air from adjacent spaces.

In a few instances two spaces were served by one terminal unit. In the event that this happened, the ratio of supply maximum and minimum for the space to total maximum and minimum was given to each space.

There were spaces where the Occupancy Category had to be assumed in order to obtain People Outdoor Air Rate (R_p) and Area Outdoor Rate (R_a) values. For instance, the Student Affairs space was assumed to have the same conditions as a conference room, therefore, the R_p and R_a values were applied to this space. Other spaces considered this way were the café, café storage, copy rooms, security, mail and ticket rooms, dressing rooms, loading dock, and the booth in the multi-purpose space.

Occupant Density (P_z) values had to be estimated as well. These values were obtained either by counting computers or furniture in a space or by #/1000 ft^2 based on table 6-1 of ASHRAE standard 62.1-2004. For the multi-purpose space 120 people were assumed.

The Occupant Diversity (D) was assumed to be 1.0. Occupant data was not available for these calculations and there was no way to determine it otherwise.

The Zone Air Distribution Effectiveness (E_z) was assumed to be 1.0 for the calculations. This was chosen based on a ceiling supply of cool air.

The Zone Primary Airflow (V_{pz}) value was assumed to be the minimum cfm based on the terminal unit schedule.

For calculations that involved Appendix A, Discharge Outdoor Air Fraction (Z_d),V_{pz} was assumed for Zone Discharge Airflow (V_{dz}).

Procedure

The procedure for determining Outdoor Air Intake (V_{ot}) is outlined in ASHRAE standard 62.1-2004. The steps listed in section 6.2 are what were followed to obtain all data within this report. Below is the step by step procedure of the analysis.

Step 1:

Gather all necessary data from drawings and schedules. This includes Floor Area (A_z) and Zone Population (P_z) for each space in the analysis. P_z values were obtained from table 6-1.

Also, obtain the People Outdoor Air Rate (R_p) and the Area Outdoor Air Rate (R_a) for the spaces being analyzed. These values are obtained from table 6-1 in the ASHRAE standard.

Step 2: **Breathing Zone Outdoor Airflow** (V_{bz})

For this procedure the data gathered in the step above is used in the following equation.

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

Step 3: **Zone Air Distribution Effectiveness** (E_z)

For the value of E_z, refer to table 6-2 of the standard.

E_z =1.0 for these calculations

Step 4: **Zone Outdoor Airflow** (V_{oz})

The data for V_{oz} is obtained by using the numbers from step 2 and step 3.

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

Step 5: **Primary Outdoor Air Fraction** (Z_p)

See assumptions section for details pertaining to V_{pz}

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

Step 6: **System Ventilation Efficiency** (E_v)

E_v is determined using table 6-3 or Appendix A. If the Value of Z_p is equal to or less than 0.55 the table 6-3 is used. If the value of Z_p is greater than 0.55 Appendix A is used to calculate the value of E_v. After determining E_v, follow step 7.

Appendix A: (If Necessary)

When using Appendix A to determine the value of E_v, First X_s and Z_d must be calculated. These are found using the following formulas.

$X_s = V_{ou} / V_{ps}$ $Z_d = V_{oz} / V_{dz}$

Where $V_{ps} = \Sigma V_{pz}$ and V_{dz} is equal to V_{pz}. See assumptions for more details pertaining to this. After these two values are calculated, E_v can be determined using the following formula.

$E_v = 1 + X_s - Z_d$

Step 7: **Uncorrected Outdoor Air Intake** (V_{ou})

$V_{ou} = D\ \Sigma_{\text{all zones}} R_p * P_z + \Sigma_{\text{all zones}} R_a * A_z$

Where: ($R_p * P_z$) and ($R_a * A_z$) values are from step 2 and D = 1.0. See Assumptions for more information on the value of D.

Step 8: **Outdoor Air Intake** (V_{ot})

This is the value compared to the design.

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

Calculations

The procedure outlined in the preceding section was followed for all calculations pertaining to this document. Each AHU is considered a zone for the purpose of these calculations. For details about this section see Assumptions and Procedure sections of this document.

For AHU-1, a Z_p value of 1.58 was obtained. This was not considered for the E_v value because it is not considered a critical space. Instead, the second highest Z_p value was used because it is considered a critical space.

The following is a calculation from AHU-2: Facilities Office
$R_p = 5.0$ cfm / person
$P_z = 4$ people / 1000 ft^2
$R_a = 0.06$ cfm
$A_z = 228$ ft^2

$V_{bz} = R_p * P_z + R_a * A_z$
(5.0)(4) + (0.06)(228) = 33.68 cfm

E_z =1.0 from table 6-2

$V_{oz} = V_{bz} / E_z$
33.68 / 1.0 = 33.68 cfm

$Z_p = V_{oz} / V_{pz}$
See Assumptions for value of V_{pz}.
33.68 / 45 = 0.75 > 0.55, use Appendix A

$V_{ou} = D\ \Sigma_{\text{all zones}} R_p * P_z + \Sigma_{\text{all zones}} R_a * A_z$
1.0(660) + (259.32) = 919.32 cfm

$X_s = V_{ou} / V_{ps}$
$V_{ps} = \Sigma V_{pz}$
919.32 / 3135 = 0.29

$Z_d = V_{oz} / V_{dz}$
$V_{dz} = V_{pz}$
919.32 / 3135 = 0.29

$E_v = 1 + X_s - Z_d$
1 + 0.29 – 0.29 = 1.0

$V_{ot} = V_{ou} / E_v$
919.32 / 1.0 = <u>919.32 cfm</u>

Discussion

AHU-1, AHU-2, and AHU-4 are a VAV system while AHU-3 is a CV system. AHU-1, AHU-2, and AHU-3 provide spaces on the first two floors with air. AHU-2 provides the multi-purpose performance space with air while AHU-3 supplies the gallery and lobby. AHU-4 provides all the studios on floors three through nine with air. All four of these AHUs were evaluated with ASHRAE standard 62.1-2004 to check for ventilation compliance. The findings of this evaluation are as follows:

AHU-1:
The total supply for AHU-1 is 18,887 cfm and the minimum outdoor air is 2,900 cfm. The calculated total outdoor air flow is 1,714 cfm and the design outdoor air intake was found to be 2,857 cfm. The calculated outdoor air is less than the design airflow therefore AHU-1 complies with ASHRAE standard 62.1 – 2004.

AHU-2:
The total supply for AHU-2 is 9,600 cfm and the minimum outdoor air is 3,250 cfm. The calculated total outdoor air flow is 919 cfm and the design outdoor air intake was found to be 919 cfm. The calculated outdoor air is less than the design airflow therefore AHU-2 complies with ASHRAE standard 62.1 – 2004.

AHU-3:
The total supply for AHU-3 is 12,000 cfm and the minimum outdoor air is 3,200 cfm. The calculated total outdoor air flow is 1,253 cfm and the design outdoor air intake was found to be 1,253 cfm. The calculated outdoor air is less than the design airflow therefore AHU-3 complies with ASHRAE standard 62.1 – 2004.

AHU-4:
The total supply for AHU-2 is 11,600 cfm and the minimum outdoor air is 7,000 cfm. The calculated total outdoor air flow is 1,461 cfm and the design outdoor air intake was found to be 2,435 cfm. The calculated outdoor air is less than the design airflow therefore AHU-4 complies with ASHRAE standard 62.1 – 2004.

The evaluation shows that all AHUs serving The Gateway at MICA meet the requirements for outdoor air ventilation according to ASHRAE standard 62.1-2004.

All charts with the information and calculations for each AHU can be found in Appendix A.

Procedure Discussion

The Ventilation Rate Procedure is the method that was used in doing the calculations for this report. This method calculates outdoor air requirement rates based on the square footage, use, and occupancy of the room. This method assumes that the air being drawn in from outdoors is fresh and that once it is in the space mixing will occur to displace any contaminants that might be in the air.

The Indoor Air Quality Method is more contaminant specific. The use of the space in analyzed in this method more than the Ventilation Rate Procedure method. The Indoor Air Quality Method takes into account what contaminants will be in the air and provides adequate ventilation to rid the space of these pollutants.

Both methods discussed work equally as well for ventilation rates. The Indoor Air Quality method would be better suited for special design cases such as laboratories, hospitals, or equipment rooms. Basically the Indoor Air Quality method is geared toward spaces that require a higher level of air quality to ensure that the air is, in fact, fresh and clean. For any other kind of analysis the Ventilation Rate Procedure will suffice.

This method is very straight forward and there is not a lot of guess work involved. With this method not nearly as much information is needed about the space as with the Indoor Air Quality Method. The fact that not as much information is needed and it is very straight forward is probably why the Ventilation Rate Procedure is most widely used in doing a ventilation analysis.

Appendix A

AHU-1

ROOM	SQ.FT. (Az)	MAX CFM	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Ez	Voz	Zp
Lobby/Prefunction	565	2220	775	17	7.5	0.06	7.56	1.0	161.40	0.21
Security	31	345	105	1	5.0	0.06	5.06	1.0	6.86	0.07
Café	1042	2945	880	25	7.5	0.18	7.68	1.0	375.06	0.43
Café Pantry	245	1100	500	3	7.5	0.18	7.68	1.0	66.60	0.13
Tickets	53	50	18	1	5.0	0.06	5.06	1.0	8.18	0.45
Mail	93	75	27	1	5.0	0.06	5.06	1.0	10.58	0.39
Telecom Entry	122	150	90	0	10.0	0.12	10.12	1.0	14.64	0.16
Catering Storage	68	640	192	0	0.0	0.12	0.12	1.0	8.16	0.04
Event Storage	130	125	38	0	0.0	0.12	0.12	1.0	15.60	0.41
Men's Dressing	114	220	65	1	5.0	0.06	5.06	1.0	11.84	0.18
Shop	932	740	220	18	10.0	0.18	10.18	1.0	347.76	1.58
Café Storage	112	100	45	0	0.0	0.12	0.12	1.0	13.44	0.30
Loading Dock	146	145	43	2	0.0	0.00	0.00	1.0	0.00	0.00
Women Dress.	103	220	65	1	5.0	0.06	5.06	1.0	11.18	0.17
Storage	285	150	44	0	0.0	0.12	0.12	1.0	34.20	0.78
Meeting Room	605	2688	800	12	5.0	0.06	5.06	1.0	96.30	0.12
Student Affairs	944	1880	565	10	5.0	0.06	5.06	1.0	106.64	0.19
Director's Office	117	225	45	1	5.0	0.06	5.06	1.0	12.02	0.27
Office	68	70	22	1	5.0	0.06	5.06	1.0	9.08	0.41
Office	86	90	29	1	5.0	0.06	5.06	1.0	10.16	0.35
Office	82	90	29	1	5.0	0.06	5.06	1.0	9.92	0.34
Conference	348	720	215	12	5.0	0.06	5.06	1.0	80.88	0.38
Office	103	90	29	1	5.0	0.06	5.06	1.0	11.18	0.39
Copy/Storage	103	160	51	1	5.0	0.06	5.06	1.0	11.18	0.22
Soft Meeting	284	440	130	6	5.0	0.06	5.06	1.0	47.04	0.36
Conference	364	544	160	12	5.0	0.06	5.06	1.0	81.84	0.51
Living Room	354	280	85	1	5.0	0.06	5.06	1.0	26.24	0.31
Bedroom 1	152	130	39	1	5.0	0.06	5.06	1.0	14.12	0.36
Bedroom 2	160	320	96	1	5.0	0.06	5.06	1.0	14.60	0.15
Director's Office	153	130	45	1	5.0	0.06	5.06	1.0	14.18	0.32
Telecom	116	225	65	0	10.0	0.12	10.12	1.0	13.92	0.21
Laundry	368	1580	475	5	5.0	0.12	5.12	1.0	69.16	0.15
		Total CFM								
	ΣAz	**ΣMax**	**ΣVpz**			**ΣRp*Pz**	**ΣRa*Az**		**ΣVoz**	
	8448	18887	5987			877.50	836.46		1713.96	
					Max Zp =>	0.51				
D =>	1.0									
					Ev =>	0.60				
Vou =>	1713.96									
					Vot =>	2856.60				

AHU-2

ROOM	SQ.FT. (Az)	MAX CFM	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Ez	Voz	Zp
Multi-Purpose	3136	9300	2900	120	5.0	0.06	788.16	1.0	788.16	0.27
Facilities Off.	228	135	45	4	5.0	0.06	33.68	1.0	33.68	0.75
Circulation	466	150	45	0	0.0	0	0.00	1.0	0	0.00
Booth	479	300	145	4	10.0	0.12	97.48	1.0	97.48	0.67
		Total CFM								
	ΣAz	ΣMax	ΣVpz	ΣPz					ΣVoz	
	4309	9885	3135	128					919.32	
	D =>	1.0		Max Zp =>		0.75	Appdx A			
	Vou =>	919.32			Ev =>	1.00				
	Xs =>	0.29		Vot=Vou/Ev						
					Vot =>	919.32				
	Zd =>	0.29								

AHU-3

ROOM	SQ.FT. (Az)	MAX CFM	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Ez	Voz	Zp
Lobby/Prefunction	2350	9235	9235	100	7.5	0.06	891.00	1.0	891.00	0.10
Gallery	1277	2628	2628	38	7.5	0.06	361.62	1.0	361.62	0.14
		Total CFM		ΣPz					ΣVoz	
		11863	11863	138					1252.62	
D =>	1.0			Max Zp =>		0.14				
Vou =>	1252.62				Ev =>	1.00				
					Vot =>	1252.62				

AHU-4

ROOM	SQ.FT. (Az)	MAX CFM	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Ez	Voz	Zp
Storage	127	280	85	0	5.0	0.12	15.24	1.0	15.24	0.18
Studio	721	1540	325	4	10.0	0.18	169.78	1.0	169.78	0.52
Studio	848	1620	450	6	10.0	0.18	212.64	1.0	212.64	0.47
Studio	848	1620	450	6	10.0	0.18	212.64	1.0	212.64	0.47
Studio	848	1620	450	6	10.0	0.18	212.64	1.0	212.64	0.47
Studio	848	1620	450	6	10.0	0.18	212.64	1.0	212.64	0.47
Studio	848	1620	450	6	10.0	0.18	212.64	1.0	212.64	0.47
Studio	848	1620	450	6	10.0	0.18	212.64	1.0	212.64	0.47
		Total CFM								
	ΣAz	**ΣMax**	**ΣVpz**	**ΣPz**					**ΣVoz**	
	5936	11540	3110	40					1460.86	
		D =>	1.00	**Max Zp =>**		0.52				
		Vou =>	1460.86		**Ev =>**	0.60				
				Vot=Vou/Ev						
					Vot =>	2434.77				

Appendix B

The Required Zone Outdoor Airflow is listed in red

ROOM	SQ.FT. (Az)	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Voz
Lobby/Prefunction	565	775	17	7.5	0.06		
Security	31	105	1	5.0	0.06		
	596	**880**	**18**	**7.5**	**0.06**	**170.76**	**170.76**
Café	1042	880	25	7.5	0.18	375.06	**375.06**
Café Pantry	245	500	3	7.5	0.18	66.60	**66.60**
Tickets	53	18	1	5.0	0.06		
Mail	93	27	1	5.0	0.06		
	146	**45**	**2**	**5.0**	**0.06**	**18.76**	**18.76**
Telecom Entry	122	90	0	10.0	0.12	14.64	**14.64**
Catering Storage	68	192	0	0.0	0.12		
Event Storage	130	38	0	0.0	0.12		
	198	**230**	**0**	**0.0**	**0.12**	**23.76**	**23.76**
Men's Dressing	114	65	1	5.0	0.06	11.84	**11.84**
Shop	932	220	18	10.0	0.18	347.76	**347.76**
Café Storage	112	45	0	0.0	0.12	13.44	**13.44**
Loading Dock	146	43	2	0.0	0.00		
Storage	285	44	0	0.0	0.12		
	431	**87**	**2**	**0.0**	**0.12**	**51.72**	**51.72**
Women's Dressing	103	65	1	5.0	0.06	11.18	**11.18**
Meeting Room	605	800	12	5.0	0.06	108.00	**108.00**
Student Affairs	944	565	10	5.0	0.06	106.64	**106.64**
Director's Office	117	45	1	5.0	0.06	12.02	**12.02**
Office	68	22	1	5.0	0.06		
Office	86	29	1	5.0	0.06		
Office	82	29	1	5.0	0.06		
	236	**80**	**3**	**5.0**	**0.06**	**29.16**	**29.16**
Conference	348	215	12	5.0	0.06	80.88	**80.88**
Office	103	29	1	5.0	0.06		
Copy/Storage	103	51	1	5.0	0.06		
	206	**80**	**2**	**5.0**	**0.06**	**22.36**	**22.36**
Soft Meeting	284	130	6	5.0	0.06	47.04	**47.04**
Conference	364	160	12	5.0	0.06	81.84	**81.84**
Living Room	354	85	1	5.0	0.06		
Bedroom 1	152	39	1	5.0	0.06		
Bedroom 2	160	96	1	5.0	0.06		
	666	**220**	**3**	**5.0**	**0.06**	**54.96**	**54.96**
Director's Office	153	45	1	5.0	0.06	14.18	**14.18**
Telecom	116	65	0	10.0	0.12	13.92	**13.92**
Laundry	368	475	5	5.0	0.12	69.16	**69.16**

ROOM	SQ.FT. (Az)	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Voz
Multi-Purpose	3136	2900	120	5.0	0.06		
Facilities Office	228	45	4	5.0	0.06		
Circulation	466	45	0	0.0	0		
Booth	479	145	4	10.0	0.12		
	4309	**3135**	**128.00**	**5.00**	**0.06**	**898.54**	**898.54**

ROOM	SQ.FT. (Az)	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Voz
Lobby/ Prefunction	2350	9235	100	7.5	0.06		
Gallery	1277	2628	38	7.5	0.06		
	3627		**138**	**7.5**	**0.06**	**1252.62**	**1252.62**

ROOM	SQ.FT. (Az)	MIN CFM (Vpz)	DESIGN OCCUP (Pz)	CFM / Person (Rp)	CFM/SQFT (Ra)	Vbz	Voz
Catering Storage	127	85	0	5.0	0.12		
Studio	721	325	4	10.0	0.18		
	848	**410**	**4**	**10.0**	**0.18**	**192.64**	**192.64**
Studio	848	450	6	10.0	0.18	**212.64**	**212.64**
Studio	848	450	6	10.0	0.18	**212.64**	**212.64**
Studio	848	450	6	10.0	0.18	**212.64**	**212.64**
Studio	848	450	6	10.0	0.18	**212.64**	**212.64**
Studio	848	450	6	10.0	0.18	**212.64**	**212.64**
Studio	848	450	6	10.0	0.18	**212.64**	**212.64**

References

"ANSI/ASHRAE Standard 62.1-2004 – Ventilation for Acceptable Indoor Air Quality." ASHRAE, Inc. Atlanta, GA. 2004.

The Gateway at MICA – plans and schedules. Bid Set Vol. 1. May 15, 2006.