Technical Assignment 1

ASHRAE Standard 62.1 2007 Ventilation Compliance Evaluation

Xanadu Meadowlands Sports Complex Building A
East Rutherford, New Jersey

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Table of Contents

Executive Summary

The American Society of Heating, Refrigerating and Air-Conditioning Engineers Standard 62.1 (ASHRAE 2007) provides a source to ensure that minimum ventilation requirements are met within a building. Proper outdoor air ventilation to spaces in the building is essential in maintaining a proper level of indoor air quality. Every day the Xanadu Meadowlands Sports Complex will entertain thousands of occupants for long periods of time. For this reason excellent indoor air quality is critical in ensuring the well being of every guest to this state of the art facility. To evaluate the effectiveness of the ventilation systems in the Xanadu Sports Complex Building A, calculations have been conducted using the ASHRAE Standard 62.1 guidelines to determine whether or not the current system meets the standards requirements.

Building A of the Xanadu complex is comprises of approximately 553,000 square feet of leasable space within its four floors. The building is divided into two sections; the south side of Building A will contain sporting good stores, restaurants, and night clubs, while the north side of the building will house America's first indoor ski resort. The retail end of the buildings receives ventilations from four rooftop air handling units (RTUs) while the Snowdome indoor ski resort is served by a single air handling unit (AHU) housed in a mechanical room adjacent to the ski resort. For this analysis, the required ventilation rates for various spaces are governed based on the peak occupancy, the use of the space, and the floor area of the space. (ASHRAE 2007)

The majority of the retail space is comprised of a single large atrium that is open from the first to third floor. Two of the RTUs will provide ventilation directly to the first and second floor walkways of the atrium while back of house rooms are to draw fresh air supplied to the atrium through corridors. Two larger RTUs supply fresh air to the third floor; however, these two units have been oversized to allow air to drop from the top of the atrium and supply more fresh air to the first and second floor. The ground floor of the retail section houses a loading dock and back of house rooms that are supplied fresh air through louvers in the exterior walls.

The ASHRAE 62.1 compliance analysis of building A revealed some potential ventilation problems. The largest problem is that ductwork only supplies fresh air to the central atrium. There is no ductwork to the other spaces which are required to have ventilation. In place of ductwork, the design is meant to have the over ventilated atrium air work its way through various passageways and corridors to the rooms in need of ventilation. Besides the air having to travel long distances through corridors, it also must try to find its

way through door cracks since there are no louvers to allow the corridor air in. This presents a problem since a minority of the rooms are equipped with exhaust fans to create a negative pressure to draw air from the corridors. Another area of concern is the placement of the return grilles. The only return grilles are placed at the top of the atrium, the same place where the majority of all the air for the building is supposed to be supplied from. This presents a large threat of short circuiting which would cause all the spaces to receive little to no ventilation. The AHU compliance summary table is listed below demonstrating how the poor air distribution in AHU-1 and AHU-2 are creating low ventilation efficiencies which increases the demand of fresh outdoor air.

Air Handeling Unit	Serves	Ventilation Efficiency	Required O.A. (cfm)	Supplied O.A. (cfm)	Meets Standard?
RTU-1	1st & 2nd Floor East Common Areas	0.6	9,410	1,358	**No**
RTU-2	1st & 2nd Floor West Common Areas	0.6	11,564	1,637	**No**
RTU-3	3rd Floor	1.0	1,515	3,039	**Yes**
RTU-4	3rd Floor	1.0	1,563	3,038	**Yes**
AHU-Snowdome	Indoor Ski Resort	1.0	48,000	15,000	**No**

Table 1: Air Handling Unit Compliance Summary

Problems arose with the natural ventilation louvers that are installed on the ground floor. In all cases either the louver-free area was too small or the louver was too close to a confinement source.

It is to be noted that many of the discrepancies in this report are due to differences from ASHRAE Standard 62.1 2007 and the Building Officials and Code Administrators 1996 code which is the governing code for this project.

Building Design Summary

Building A of the Meadowlands Xanadu complex is designated as the sports district. All sports related retail stores and activities will be housed in this building. Building A has essentially two sections; the south side of Building A will contain all retail stores while the north side of the building will house the Snowdome indoor ski resort.

The retail section of Building A will contain a wide variety of sporting goods stores, a restaurant, and night clubs. The majority of leasable space will be used for retail sales; however, these retail spaces are not included in the current contract. Therefore, for these types of spaces an analysis will not be applicable. Required ventilation calculations were still performed for these spaces and can be found in the Appendix. All work in retail spaces, night clubs, the ski resort lodge, and the restaurant will be fit out by the tenant near the end of construction.

The north section of Building A will house The United States' first indoor ski resort named the Snowdome. During normal operation the slopes will be comprised of snow laying flat over the distance of the run. However, during special events the slopes can be made into quarter pipes, and jumps can be added for competitions. Aside from skiing and snowboarding competitions the Snowdome is planned to be used for concerts, fashion shows, and parties with a wintery touch. The Snowdome will house 160,000 square feet of cold side space and will include a novice ski slope at 330 feet long by 120 feet wide and an advanced ski slope at 780 feet long and 150 feet wide. During times of normal operation the peak occupancy load is expected to be 300, while during special events the space was designed to provide enough fresh air for 999 people.

Figure 1 below shows the occupancy category break down for the building as prescribed by ASHRAE 62.1. (ASHRAE 2007)

Figure 1: ASHRAE 62.1 Occupancy Category Distributions

Snowdome Mechanical System Summary

The challenge of an indoor ski resort is to ensure that snow can be maintained year round and a highly controlled environment is achieved. During normal day operation, temperatures must be maintained between 30°F and 32°F. However, at night, fresh snow is made on a daily schedule, and temperatures must be cooled to approximately 24°F to ensure proper snow making. The Snowdome mechanical system is planned to achieve proper conditions by using cooled supply air, under floor glycol piping, ceiling mounted recirculation coolers, and snow guns.

The Snowdome ventilation system is comprised of a single 30,000 cfm air handling unit with 15,000 cfm of the supply air being outside air. The unit uses a main common intake system with one primary and two secondary cooling coils. The air is pre-cooled by means of a thermal wheel and then cooled down to above freezing by the primary cooling coil. The air is then cooled below freezing by the secondary coils which are fed by a cold glycol system. A hot glycol system line is also fed to the secondary coils and will only be used when the coils need to be defrosted. The system is fully variable in volume, achieved by using inverters on the fans, to suit the current occupancy.

Two 222 ton electric screw chillers operating at 1.5°F leaving glycol temperature provides the cold glycol to the air handling unit's coils, under floor piping matrix, recirculation coolers, and snow guns. Both chillers operate in conjunction with an evaporative condenser located on the roof of the Snowdome mechanical mezzanine which houses all the Snowdome's mechanical equipment.

Mounted along the ceiling of the Snowdome are recirculation coolers and snow guns. Both devices will be run using the cold glycol system during normal operation. However, when the devices need to be defrosted, the cold glycol system will be shut off and the hot glycol system will be turned on to all for defrosting. The snow guns also require compressed air for the use of snow making; therefore, a compressed air line will be provided to each snow gun.

Retail Mechanical System Summary

The air side mechanical system for the retail section of Building A uses four roof top air handling units that serve all the common areas of the building. In Building A common spaces are comprised of walkways to the different stores and restaurants, restrooms, back of house rooms, and a large central area that will create a large atrium for all the levels of shopping. All tenant spaces will not have any mechanical work done at this time and will be finished by the leaser towards the completion of the building. All four common area rooftop units are controlled by variable frequency drives with two running modes: occupied mode during normal operating hours and unoccupied mode during the nighttime. A programmable time clock will control when the occupied or unoccupied mode begins to run. A thermostat will control the cycling of the supply fan and energize the electric heating coil to maintain the nighttime setback temperature during the unoccupied mode. During the occupied mode the supply fan will operate continuously. The use of an economizer to maximize atmospheric cooling has also been implemented for all four of the rooftop units

RTU-1 serves the first and second floor common areas on the east side of the building, and RTU-2 serves the first and second floor common areas on the west side of the building. Both units supply 16,100 cfm of air each with 1,496 cfm of that supply air being outside air. Each unit's cooling coil has a capacity of approximately 38 tons and an electric heating coil capacity of 150 kilowatts. RTU-3 and RTU-4 serve the third floor common areas. Both of these units supply 31,000 cfm of air each with 3,037 cfm of that supply air being outside air. Each unit's cooling coil has a capacity of approximately 78 tons and an electric heating coil capacity of 190 kilowatts. A graphical representation of the atriums ventilation system can be seen in Figure 2.

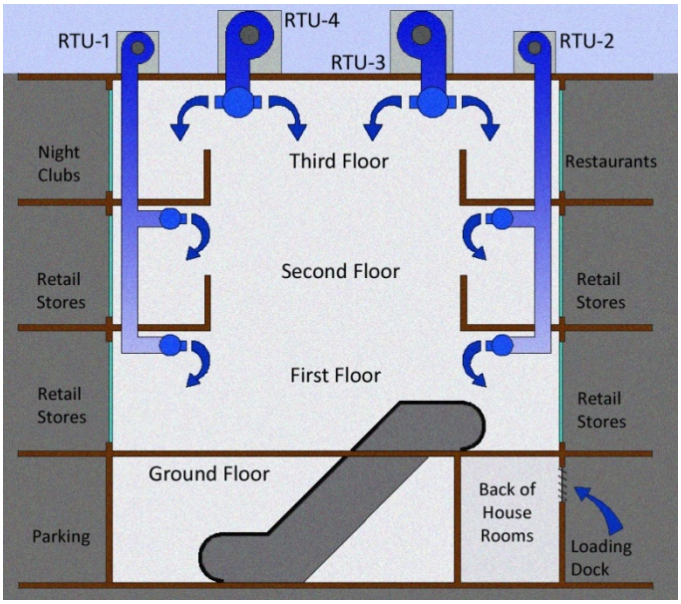

Figure 2: Retail Ventilation

In addition to the rooftop units, wall mounted electric unit heaters are used in mechanical spaces, entrance vestibules and exit stairways to maintain thermal comfort. To ensure fresh air enters the back of house rooms, exhaust fans are installed to negatively pressurize the rooms. With the use of exhaust fans, fresh air that has been supplied to the walkways on the floor will be drawn to the rooms with negative pressure. Small air condition units are also used in elevator machine rooms and the main ground floor entrance to supply cooling when needed.

Section Five Compliance Analysis

Section five of ASHRAE 62.1 covers system and equipment requirements ranging from natural ventilation requirements to contaminant isolation. The natural ventilation requirements for Building A are an important section. While the first, second, and third floor have a mechanical ventilation system the ground floor relies primarily on louvers in the exterior walls to provide outside air to spaces. Naturally ventilated spaces are covered in section 5.1 of ASHRAE 62.1 and states that spaces with direct openings to the outside must have an opening of 4% of the space's floor area. For spaces that receive natural ventilation indirectly through other rooms the free opening must be a minimum of 8% of the spaces floor are or 25 square feet. (ASHRAE 2007) Table 2 lists all spaces on the ground floor without a mechanical ventilation system and whether or not the space complies with ASHRAE 62.1 natural ventilation requirements.

Table 2: Naturally Ventilated Space Compliance

		ASHRAE 62.1				Design Case		
Room	Space	Area (SF)	Natural Ventilation		Required Opening (SF)	Opening (SF)	Meets Standard?	Notes:
			Direct	In-Direct				
A 005	Atrium Entrance	2,101	-	-	84	0	**No**	1
A 006	Electrical Equip.	470	X		19	1	**No**	2
A 007	Telecom Room	178	-	-	7	0	**No**	
A 008	Electrical Equip.	244	X		10	1	**No**	2
A 009	Electrical Equip.	692	X		28	3	**No**	3
A 010	Telecom Room	327	-	-	13	0	**No**	
A 011	Water Room	294	-	-	12	0	**No**	
A 012	Electrical Equip.	383	-	-	15	9	**No**	3

1. Open to the atrium spaces on the above floors
2. Louver is open to the adjacent loading dock
3. Louver is open to the adjacent parking garage

It should be noted that the louvers installed in exterior walls are within 25 feet of a loading dock and will draw high levels of exhaust into the spaces. The location of louvers fails the Air Intake Minimum Separation Distance which can be found in Table 5 of ASHRAE 62.1 (ASHRAE 2007). This section requires that any opening that is to be used for air intake be at a minimum of 25 feet from truck loading docks, which in this case is closer than the requirement.

Space Ventilation Rate Analysis

For the majority of the spaces found in Building A the Ventilation Rate Procedure will be used to calculate ventilation rates as prescribed by section six in ASHRAE 62.1. (ASHRAE 2007) The use of the Ventilation Rate Procedure determined ventilation rates based on space application, occupancy levels, and floor area. While the floor areas where easily obtained through the architectural drawings, the other two variables were found using various assumptions. To determine space applications, occupancy categories were chosen using the closet match of category. Spaces such as the indoor ski resort and the sky diving simulator present a challenge in accurately finding a prescribed ventilation rate. Table 3 lists the room types present in Building A and the occupancy category assigned to the space.

	ASHRAE 62.1 2007			
Room Type	**Occupancy Category**	**People O.A. (cfm / Person)**	**Area O.A. (cfm / SF)**	**Occupancy Density (People / 1000 SF)**
Stores	Retail Sales	7.5	0.12	15
Walkways	Mall Common Areas	7.5	0.06	40
Utility	Electrical Equipment	0	0.06	0
Exit Passageways	Corridors	0	0.06	0
Janitor Closets	Storage	0	0.12	0
Ski Resort	Gym (Play Area)	0	0.3	30
Sky Diving Sim.	Gym (Play Area)	0	0.3	30
Restaurant	Restaurant	7.5	0.18	70
Night Clubs	Dance Floors	20	0.06	100

Table 3: Assigned Occupancy Categories

Once an occupancy category was chosen for a space, the occupancy level could be obtained. Since original design loads were not available the occupancy density prescribed by ASHRAE 62.1 Table 1 (ASHRAE 2007) was used. The occupancy densities used in this analysis are shown in Table 3.

To compare the required ventilation rates found from ASHRAE 62.1 (ASHRAE 2007), the flow rate through each diffuser in the space were summed. To determine the amount of the air that was fresh air, the outdoor air flow rate was obtained from the schedule for the air handling unit that is serving the space. A summary of the analysis broken down by air handling unit can be found in Table 4 through Table 8. These tables only provide a small sample of the calculations for this analysis. A more detailed calculation table with all factors and variables defined can be found in Appendix A.

Table 4: Spaces Served by Roof Top Unit 1

		ASHRAE 62.1			Design Case		
Room	**Space**	**Area (SF)**	**Occupancy Level (People)**	**Required O.A. (cfm)**	**Supplied O.A. (cfm)**	**Meets Standard?**	**Notes:**
A 105	Central Atrium	9,820	393	5892	651	**No**	
A 106	Electrical Equip.	453	0	45	0	**No**	1, 2, 3
A 107	Exit Passageway	863	0	86	0	**No**	1
A 108	Telecom Room	284	0	28	0	**No**	1
A 205	Central Atrium	5,136	205	3082	753	**No**	
A 206	Electrical Equip.	466	0	47	0	**No**	1, 2, 3
A 207	Exit Passageway	1,125	0	113	0	**No**	1
A 208	Telecom Room	282	0	28	0	**No**	1

1. There is no direct ventilation to this space
2. Exhaust fan is installed to create negative pressure and draw air from outside the room
3. The space the exhaust air is drawing air from is under-ventilated o not directly ventilated

Table 5: Spaces Served by Roof Top Unit 2

		ASHRAE 62.1			Design Case		
Room	**Space**	**Area (SF)**	**Occupancy Level (People)**	**Required O.A. (cfm)**	**Supplied O.A. (cfm)**	**Meets Standard?**	**Notes:**
A 101	Corridor	287	11	172	0	**No**	1
A 105	Central Atrium	8,695	348	5217	744	**No**	
A 109	Electrical Equip.	487	0	49	0	**No**	1, 2, 3
A 110	Electrical Equip.	292	0	29	0	**No**	1
A 111	Corridor	1,389	0	139	0	**No**	1
A 112	Storage	75	0	15	0	**No**	1, 2, 3
A 116	Storage	438	0	88	0	**No**	1
A 201	Corridor	298	12	179	0	**No**	
A 205	Central Atrium	9,128	365	5477	753	**No**	
A 209	Electrical Equip.	422	0	42	0	**No**	1, 2, 3
A 210	Electrical Equip.	236	0	24	0	**No**	1
A 211	Corridor	1,187	0	119	0	**No**	1
A 212	Storage Room	75	0	15	0	**No**	1, 2, 3

1. There is no direct ventilation to this space
2. Exhaust fan is installed to create negative pressure and draw air from outside the room
3. The space the exhaust air is drawing air from is under-ventilated o not directly ventilated

Table 6: Spaces Served by Roof Top Unit 3

		ASHRAE 62.1			Design Case		
Room	**Space**	**Area (SF)**	**Occupancy Level (People)**	**Required O.A. (cfm)**	**Supplied O.A. (cfm)**	**Meets Standard?**	**Notes:**
A 302	Corridor	3,398	0	204	0	**No**	1
A 305	Central Atrium	3,535	141	1,273	3,039	**Yes**	
A 309	Electrical Equip.	412	0	25	0	**No**	1, 2, 3
A 310	Electrical Equip.	237	0	14	0	**No**	1

1. There is no direct ventilation to this space
2. Exhaust fan is installed to create negative pressure and draw air from outside the room
3. The space the exhaust air is drawing air from is under-ventilated o not directly ventilated

Table 7: Spaces Served by Roof Top Unit 4

		ASHRAE 62.1			Design Case		
Room	**Space**	**Area (SF)**	**Occupancy Level (People)**	**Required O.A. (cfm)**	**Supplied O.A. (cfm)**	**Meets Standard?**	**Notes:**
A 305	Central Atrium	6,542	262	2,355	3,038	**Yes**	
A 306	Electrical Equip.	338	0	20	0	**No**	1, 2, 3
A 307	Exit Passageway	1,210	0	73	0	**No**	1
A 308	Electrical Equip.	284	0	17	0	**No**	1

1. There is no direct ventilation to this space
2. Exhaust fan is installed to create negative pressure and draw air from outside the room
3. The space the exhaust air is drawing air from is under-ventilated o not directly ventilated

Table 8: Snowdome AHU

		ASHRAE 62.1			Design Case		
Room	**Space**	**Area (SF)**	**Occupancy Level (People)**	**Required O.A. (cfm)**	**Supplied O.A. (cfm)**	**Meets Standard?**	**Notes:**
Snowdome	Snowdome	160,000	999	48,000	15,000	**No**	1, 2

1. Peak load will occur during special events housed within the Snowdome
2. Occupany level is known for special events, no assumptions where made

Besides ventilation rates, minimum exhaust air rates are required for specific spaces. Table 6-4 in ASHRAE 62.1 covers the requirements needed. Table 9 below summarizes the analysis for spaces in Building A that need a minimum exhaust rate.

Table 9 : Exhaust Rate Compliance

		ASHRAE 62.1					Design Case	
Room	Space	Area (SF)	Exhaust Rate (cfm/SF)	Exhaust Rate (cfm/unit)	Units	Required Exhaust (cfm)	Exhaust (cfm)	Meets Standard?
A 112	Janitors Closet	75	1	-		75	100	Yes
A 113	Womens Room	488	-	70	11	770	800	Yes
A 114	Mens Room	483	-	70	8	560	950	Yes
A 212	Janitors Closet	75	1	-		75	100	Yes
A 213	Womens Room	475	-	70	11	770	800	Yes
A214	Mens Room	498	-	70	8	560	950	Yes

Discussion of Results

The results from the ventilation calculations as prescribed by ASHRAE 62.1 Ventilation Rate Procedure show some potential problems in the mechanical system when it comes to proper ventilation. The roof top units that serve the retail section of the building dump the majority of all the air from the units directly into the large atrium space and nowhere else. This design reduces the amount of ductwork needed and essentially uses the corridors as the duct to carry ventilation air to spaces. This can present a problem since in some cases spaces are relying on air to travel from the atrium though hundreds of feet of corridors to spaces that need ventilation. On top of the long distances the air must travel to corridors. The majority of rooms that are supposed to receive ventilation through the corridors are not negatively pressurized; therefore, it is practical that many of these spaces will never see ventilation. Since the only ductwork that exists serves the atrium and ignores branches of the building, the system efficiency used to calculate the total required ventilation is very low. This is causing much higher ventilation rates to all spaces served by RTU-1 and RTU-2.

It can be noted that assumptions where made on occupancy levels from the ASHRAE default occupancy density which may change the amount of ventilation needed in spaces, however, for this particular problem no direct ventilation from ducted diffuses are provided to spaces other than the atrium and mall walkways. It is fully possible that the over ventilated atrium air does reach the rooms that need ventilation through the corridors, but this type of design does not satisfy the principle of ASHRAE 62.1.

The Snowdome's air handling unit seems to be very undersized for the amount of ventilation that will be needed for such a large space. Using the Ventilation Rate Procedure, the current amount of outdoor air needs to be increased 3.2 times. Discrepancies may have been caused from the assumption of the occupancy category or also from the variations from ASHRAE 62.1 2007 and the code used to design this project which is Building Officials and Code Administrators (BOCA) 1996.

The natural ventilation analysis of the ground floor also shows some areas that can potentially be under ventilated. Three of the spaces are to be ventilated using natural ventilation that would be delivered through louvers on the exterior walls; however, the free area of the louvers is very small in comparison to the minimum requirements presented by ASHRAE 62.1. Besides not meeting the size requirements, the louvered natural ventilation also fails the Air Intake Minimum Separation Distance which can be found in Table 5 of ASHRAE 62.1 (ASHRAE 2007). This section requires that any opening

that is to be used for natural ventilations be at a minimum of 25 feet from truck loading docks, which in this case is closer than the requirement. The rest of the spaces on the ground floor are completely closed off and do not have either exterior louvers or interior louvers to gain ventilation from other rooms.

Solutions Proposal

In future assignments I plan to address many of the issues that arose during the ventilation analysis. The largest issue to resolve will be ensuring all spaces are getting the proper ventilation needed. For the retail section additional ductwork can be placed to direct the air from the units to spaces that currently do not have a mechanical ventilation system. I also plan on doing a case study on the current ventilation system using computation fluid dynamics to find if the air dumped into the central atrium does eventually find its way to the furthest corner of the building.

The Snowdome's single air handling unit may need to become multiple units in a redesign. Not only will this provide the proper ventilation needed for nearly a thousand people to ski but also, it will ensure that if something goes wrong with one of the units, air can still be supplied to the space.

Another area to investigate will be the natural ventilation on the ground floor. All naturally ventilated spaces did not meet ASHRAE 62.1 free open area and air intake minimum separation distance requirements. This will need to be addressed either by increasing the size of the louvers and moving the location to an area away from the loading dock and parking or by mechanically ventilating the space. Since all of these spaces are surrounded by potential sources of contaminants the latter option may be the best solution.

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.

Turner Construction Company. 2007, Mechanical Construction Documents. Turner Construction Company, East Rutherford, NJ. 2007.

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Appendix A - Definitions

The following definitions are found in ASHRAE 62.1 (ASHRAE 2007) and are used in the ventilation calculations in the Appendix.

A_z - Zone Floor Area: the net occupiable floor area of the zone, in square feet

E_v – System Ventilation Efficiency: the efficiency with which the system distributes air from the outdoor air intake to the breathing zone in the ventilation-critical zone, which requires the largest fraction of outdoor air in the primary air stream. Found using the Table 6-3 in ASHRAE 62.1 (ASHAE 2007)

E_z – Zone Air Distribution Effectiveness: a measure of how effectively the zone air distribution uses its supply air to maintain acceptable air quality in the breathing zone. Found using the type of system air delivery and Table 6-2 in ASHRAE 62.1 (ASHAE 2007)

R_a – Area Outdoor Air Rate: the outdoor airflow rate per unit area to be provided in the breathing zone to dilute contaminants that are emitted at a rate that is elated more to floor area than to populations. Found using Table 6-1 in ASHRAE 62.1 (ASHAE 2007)

R_p - People Outdoor Air Rate: the outdoor airflow rate per person to be provided in the breathing zone to dilute contaminants that are emitted at a rate that is related more to population than to floor area. Found using Table 6-1 in ASHRAE 62.1 (ASHAE 2007)

V_{bz} –Breathing Zone Outdoor Airflow: the outdoor airflow required in the breathing zone of an occupiable space

V_{ot} –Outdoor Air Intake Rate: the design outdoor airflow required at the ventilation system outdoor air intake

V_{ou} –Uncorrected Outdoor Air Intake: the outdoor air intake flow required if the system ventilation efficiency where 1.0

V_{oz} – Zone Outdoor Airflow: the design outdoor airflow required in the zone

V_{pz} – Zone Primary Airflow: the primary airflow supplied to the zone from the air-handling unit at which the outdoor air intake is located. It includes outdoor intake air and recirculation air from the air-handling unit but does not include air transferred or air recirculated to the zone by other means.

Appendix B – Ventilation Rate Procedure

The following appendix is a brief summary of the ventilation rate procedure outlined in ASHRAE 62.1. Definitions for all variables used can be found in Appendix A.

Breathing Zone Outdoor Airflow (V_{bz})

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

For this analysis:

The R_p and R_a values for given occupancy categories can be found in Table 3.
A_z values can be found for individual spaces from Table 4 to Table 8.
P_z is a function of A_z and the default occupancy densities found in Table 3.

Zone Air Distribution Effectiveness (E_z)

$$E_z = 1.0$$

For this analysis:

The zone air distribution effectiveness is obtained through Table 6-2 in ASHRAE 62.1 (ASHRAE 2007). From the said table a value of 1.0 is achieved since the system throughout building A is an overhead duct system.

Zone Outdoor Airflow (V_{oz})

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

Primary Outdoor Air Fraction (Z_p)

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

For this analysis:

V_{pz} is the total amount of air flow entering the space from the air handling unit and will vary per space. V_{pz} values can be found in Apendix C.

System Ventilation Efficiency (E_v)

E_v is a function of the highest Z_p value for spaces served by an air handling unit. Given a max Z_p value, Table 6-3 in ASHRAE 62.1 (ASHRAE 2007) can be used to obtain the air handling units E_v. Table 10 below lists each multi-space systems E_v.

Air Handeling Unit	Room	Voz (cfm)	Vpz (cfm)	Zp	Ev
RTU-1	A 105	3535	7,000	**0.51**	**0.6**
RTU-1	A 205	1849	8,100	0.23	**0.6**
RTU-2	A 105	3130	7,000	0.45	**0.6**
RTU-2	A 205	3286	6,600	**0.50**	**0.6**
RTU-3	A 305	1273.0	31,008	**0.04**	**1.0**
RTU-4	A 305	2355.0	29,792	**0.08**	**1.0**

Table 10: AHU E_v Summary

Appendix C – Ventilation Rate Procedure Calculation

Xanadu Meadowlands Sports Complex Building A First Floor

ASHRAE 62.1 2007 Minimum Ventilation Calculations

Zone Identification				ASHRAE Standard 62.1 2007								Design Case			
Number	Occupancy Category	Served By	Area (SF)	Rp	Ra	Occ.	Vbz (cfm)	Ez	Voz (cfm)	Ev	Vot (cfm)	Zp	Vpz (cfm)	O.A. (cfm)	Meets Standard?
A 101	Mall Cm	RTU-A2	287	7.5	0.06	11	103	1.0	103	0.60	172	0.00	0	0	**No**
A 105	Mall Cm	RTU-A1	9,820	7.5	0.06	393	3535	1.0	3535	0.60	5892	0.51	7000	651	**No**
A 105	Mall Cm	RTU-A2	8,695	7.5	0.06	348	3130	1.0	3130	0.60	5217	0.45	7000	744	**No**
A 106	Elec.	RTU-A1	453	0	0.06	0	27	1.0	27	0.60	45	0	0	0	**No**
A 107	Corr.	RTU-A1	863	0	0.06	0	52	1.0	52	0.60	86	0	0	0	**No**
A 108	Elec.	RTU-A1	284	0	0.06	0	17	1.0	17	0.60	28	0	0	0	**No**
A 109	Elec.	RTU-A2	487	0	0.06	0	29	1.0	29	0.60	49	0	0	0	**No**
A 110	Elec.	RTU-A2	292	0	0.06	0	18	1.0	18	0.60	29	0	0	0	**No**
A 111	Corr.	RTU-A2	1,389	0	0.06	0	83	1.0	83	0.60	139	0	0	0	**No**
A 112	Storage	RTU-A2	75	0	0.12	0	9	1.0	9	0.60	15	0	0	0	**No**
A 113	-	RTU-A2	488	0	0	0	0	1.0	0	0.60	0	0	0	0	**No**
A 114	-	RTU-A2	483	0	0	0	0	1.0	0	0.60	0	0	0	0	**No**
A 116	Storage	RTU-A2	438	0	0.12	0	53	1.0	53	0.60	88	0	0	0	**No**
A 117	Retail	Tenant Unit	78,178	7.5	0.12	1173	18176	1.0	18176	1.00	18176	Not in Contract			
A 117c	Retail	Tenant Unit	3,920	7.5	0.12	59	911	1.0	911	1.00	911	Not in Contract			
A 118	Corr.	RTU-A1	889	0	0.06	0	53	1.0	53	0.60	89	0.00	0	0	**No**
A 119	Elec.	Tenant Unit	6,426	0	0.06	0	386	1.0	386	1.00	386	Not in Contract			
A 120a	Retail	Tenant Unit	20,498	7.5	0.12	307	4766	1.0	4766	1.00	4766	Not in Contract			
A 120b	Retail	Tenant Unit	12,996	7.5	0.12	195	3022	1.0	3022	1.00	3022	Not in Contract			
A 120c	Retail	Tenant Unit	11,297	7.5	0.12	169	2627	1.0	2627	1.00	2627	Not in Contract			

Xanadu Meadowlands Sports Complex Building A Second Floor

ASHRAE 62.1 2007 Minimum Ventilation Calculations

Zone Identification				ASHRAE Standard 62.1 2007								Design Case			
Number	Occupancy Category	Served By	Area (SF)	Rp	Ra	Occ.	Vbz (cfm)	Ez	Voz (cfm)	Ev	Vot (cfm)	Zp	Vpz (cfm)	O.A. (cfm)	Meets Standard?
A 201	Mall Cm	RTU-A2	298	7.5	0.06	12	107	1.0	107	0.60	179	0.00	0	0	**No**
A 205	Mall Cm	RTU-A1	5,136	7.5	0.06	205	1849	1.0	1849	0.60	3082	0.23	8100	753	**No**
A 205	Mall Cm	RTU-A2	9,128	7.5	0.06	365	3286	1.0	3286	0.60	5477	0.50	6600	753	**No**
A 206	Elec.	RTU-A1	466	0	0.06	0	28	1.0	28	0.60	47	0	0	0	**No**
A 207	Corr.	RTU-A1	1,125	0	0.06	0	68	1.0	68	0.60	113	0	0	0	**No**
A 208	Elec.	RTU-A1	282	0	0.06	0	17	1.0	17	0.60	28	0	0	0	**No**
A 209	Elec.	RTU-A2	422	0	0.06	0	25	1.0	25	0.60	42	0	0	0	**No**
A 210	Elec.	RTU-A2	236	0	0.06	0	14	1.0	14	0.60	24	0	0	0	**No**
A 211	Corr.	RTU-A2	1,187	0	0.06	0	71	1.0	71	0.60	119	0	0	0	**No**
A 212	Storage	RTU-A2	75	0	0.12	0	9	1.0	9	0.60	15	0	0	0	**No**
A 213	-	RTU-A2	475	0	0	0	0	1.0	0	0.60	0	0	0	0	**No**
A 214	-	RTU-A2	498	0	0	0	0	1.0	0	0.60	0	0	0	0	**No**
A 216	Retail	Tenant Unit	60,033	7.5	0.12	900	13958	1.0	13958	1.00	13958	Not in Contract			
A 218	Gym	Tenant Unit	6,834	0	0.3	0	2050	1.0	2050	1.00	2050	Not in Contract			
A 219a	Lobbies	Tenant Unit	26,812	5	0.06	4022	21718	1.0	21718	1.00	21718	Not in Contract			
A 219b	Retail	Tenant Unit	7,724	7.5	0.12	116	1796	1.0	1796	1.00	1796	Not in Contract			
A 219c	Retail	Tenant Unit	9,013	7.5	0.12	135	2096	1.0	2096	1.00	2096	Not in Contract			

Xanadu Meadowlands Sports Complex Building A Third Floor

ASHRAE 62.1 2007 Minimum Ventilation Calculations

Zone Identification				ASHRAE Standard 62.1 2007								Design Case			
Number	Occupancy Category	Served By	Area (SF)	Rp	Ra	Occ.	Vbz (cfm)	Ez	Voz (cfm)	Ev	Vot (cfm)	Zp	Vpz (cfm)	O.A. (cfm)	Meets Standard?
A 302	Corr.	RTU-A3	3,398	0	0.06	0	204	1.0	204	1.00	204	0.00	0	0	**No**
A 305	Mall Cm	RTU-A3	3,535	7.5	0.06	141	1273	1.0	1273	1.00	1273	0.04	31008	3039	**Yes**
A 305	Mall Cm	RTU-A4	6,542	7.5	0.06	262	2355	1.0	2355	1.00	2355	0.08	29792	2920	**Yes**
A 306	Elec.	RTU-A4	338	0	0.06	0	20	1.0	20	1.00	20	0.00	0	0	**No**
A 307	Corr.	RTU-A4	1,210	0	0.06	0	73	1.0	73	1.00	73	0.00	0	0	**No**
A 308	Elec.	RTU-A4	284	0	0.06	0	17	1.0	17	1.00	17	0.00	0	0	**No**
A 309	Elec.	RTU-A3	412	0	0.06	0	25	1.0	25	1.00	25	0.00	0	0	**No**
A 310	Elec.	RTU-A3	237	0	0.06	0	14	1.0	14	1.00	14	0.00	0	0	**No**
A 316	Retail	Tenant Unit	57,402	7.5	0.12	861	13346	1.0	13346	1.00	13346	Not in Contract			
A 318	Retail	Tenant Unit	7,016	7.5	0.12	105	1629	1.0	1629	1.00	1629	Not in Contract			
A 319a	Rest.	Tenant Unit	26,921	7.5	0.18	1884	18979	1.0	18979	1.00	18979	Not in Contract			
A 319b	Dance Fl.	Tenant Unit	8,832	20	0.06	883	18194	1.0	18194	1.00	18194	Not in Contract			
A 319c	Retail	Tenant Unit	10,893	7.5	0.12	163	2533	1.0	2533	1.00	2533	Not in Contract			
A 319d	Dance Fl.	Tenant Unit	6,962	20	0.06	696	14342	1.0	14342	1.00	14342	Not in Contract			
-	Gym	-	160,000	0	0.3	999	48000	1.0	48000	NA	48000	NA	30000	15000	**No**