Technical Assignment #1

ASHRAE Standard 62.1-2004 Ventilation Compliance Evaluation Report

Hilton Hotel at BWI Airport
Linthicum Heights, MD

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Mechanical Option

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Executive Summary

The Ventilation Rate Calculation Procedure from ASHRAE Standard 62.1-2004 is used to determine whether the Hilton Hotel at BWI Airport complies with the prescribed ventilation requirements at design conditions. The Hilton Hotel at BWI Airport is a 277,000 gross square foot full-service hotel with eleven stories and a penthouse above grade and one below grade parking garage level.

Supply air is delivered to the hotel by four air-handling units (AHU), which range in size from 7500 cfm to 25,000 cfm. The amount of minimum outside air to the four AHUs varies between 2000 cfm and 16,000 cfm. The ventilation effectiveness is 1.0 based on the air distribution configuration with ceiling supply of cool air. A comprehensive summary of the building's mechanical systems is included to provide background information on the hotel's design in the Mechanical System Summary section.

As described in the Discussion section, only one of the four AHUs meet the standard and the other three AHUs do not comply with Standard 62.1-2004. AHU-1 has a minimum outdoor air quantity greater than the required design outdoor air intake flow. However, AHU-2, AHU-3, and AHU-4 all had unit minimum outdoor air quantities less than the required outdoor air intake flows. As a result, only AHU-1 is compliant with the minimum outside air requirements of ASHRAE Standard 62.1-2004, but AHU-2, AHU-3, and AHU-4 are not compliant.

Mechanical System Summary

The primary air-side components of the mechanical system on the ground and second floors use a VAV system with reheat hot water coils at the boxes in the public and service spaces.

One air handling unit and one rooftop unit on the north side roof of the ground floor provide conditioned air to many of the spaces on the ground level. Also located on the same roof is a make-up air unit to provide adequate ventilation to the kitchen. A long string of linear slot diffusers provide the required amounts of supply air to the spaces from above the large areas of windows in the pre-function area, meeting rooms, coffee bar, and restaurant. Since the sidewall supply registers in the lobby seating area dispense the necessary quantity of supply air, a parallel system of fin tube radiators help to balance the heat loss from the large sections of windows located along the exterior walls.

The second floor mechanical room houses several pieces of large mechanical equipment. One air handling unit (AHU) conditions air for the large double-story height meeting rooms, smaller meeting rooms, and the pre-function area on the ground floor. A second AHU services many of the employee services rooms and offices on the ground floor. Also in the same mechanical room is a pool dehumidifier unit that conditions for the swimming pool area. A rooftop unit on the ground level roof conditions air for several of the laundry and service spaces that are on the second floor. From the mechanical room on the northeast corner of the second floor, another AHU provides air to the offices, meeting rooms, and exercise room/health club.

On the third through eleventh floors, all the guest rooms are equipped with individual water source heat pumps, master thermostats, and control valves in each room. Through the process of value engineering, two air conditioning units located in the penthouse, which were originally scheduled to supply each guest room with 60 cfm of outside air, and all the related ductwork and fire dampers were eliminated.

The positive pressure in both stairwells is maintained by two stair pressurization fans that deliver 11,700 cfm to each stairway. The pressurization required in the corridors on the third through eleventh floors is maintained by three rooftop units located in the penthouse. These rooftop units also provide supply air to the housekeeping areas on all the guest room floors.

Exhaust registers in all of the guest room bathrooms are ducted to sub-ducts and then tapped into the exhaust stacks. There are a total of 17 main toilet exhaust riser stacks connected to toilet exhaust fans mounted on either the eleventh floor roof or the penthouse roof. This sub-duct method, which received a variance prior to design and construction, aims to prevent the spread of smoke to the other guest room floors without using smoke dampers in each of the ducts.

The primary water-side components of the mechanical system include the condenser water system and the hot water system. Due to initial budget constraints, the originally designed chilled water system was eliminated along with two water cooled chillers and two chilled water pumps. Two open-cell cooling towers are located on the north side of the building on grade with the ground floor level. These cooling towers provide condenser water to the air handling units and guest room water source heat pumps. Each heat pump is tapped off 1-1/2 inch supply and return piping, and it also has 1 inch drain piping. The condenser water is then looped back to the cooling towers through a reverse return system through 8 inch piping.

Three fossil-fuel boilers in the parking level mechanical room provide hot water for all the reheat coils in the VAV boxes, the freeze protection pumps for the air handling units, and the pool dehumidifier unit. Other pieces of equipment served by the hot water are the unit heaters, finned tube radiators, and hot air curtains located in the vestibules.

To achieve adequate ventilation of the automotive exhaust fumes in the parking level, two large outside air louvers located on the west side of the parking area draw 20,000 cfm. The mixed air is drawn out of the parking area through garage exhaust fans located on the east side of the building.

The large mechanical room located on the north side of the parking level contains much of the water-side equipment used in the hotel. This includes three boilers and their corresponding pumps, two condenser water pumps, one sedimentation separator filter, two plate and frame heat exchangers, two hot water pumps with variable frequency drives, two diaphragm expansion tanks, and some other pieces of equipment.

All sequences of controls for the entire building are performed by direct digital controls (DDC). This DDC system monitors all the sensors, and it is able to adjust all the set points and time delays for the equipment. The DDC system also provides start/stop, speed control, monitoring, and alarms for the variable frequency drives (VFD).

Assumptions

ASHRAE Standard 62.1-2004 Table 6-1 was used exclusively to obtain the required information for the minimum ventilation rates in the breathing zone. If a space in the hotel did not exactly match one of the provided spaces in the table, an assumption was made to estimate the ventilation to it. These assumptions are described below. Any of the necessary adjustments to values found in Table 6-1 were also noted. Justification and the reasoning used behind all adjustments and assumptions were described.

In many of the zones, a variable air volume (VAV) box served more than one space. The actual spaces included in the zones can be seen in the "Space Characteristics" spreadsheet in Appendix A. It was assumed that the outside air requirements for that box should correspond to those of the most important space that it serves. For example, in many cases, it was assumed that either lobby/pre-function or office space requirements were more critical than storage rooms, corridors, or toilets. However, if there were more storage rooms or toilets in a zone than office spaces, then that type of space was used instead of the office space.

In order to obtain the supply air values for all the spaces in the building, all the diffuser air quantities in each space were added together. However, there were several instances where the added up values were different from the supply air quantity listed as coming from the respective VAV boxes. The total amounts of supply air from the diffusers in the space were used for the calculations. This was consistently done throughout the entire building.

Guest rooms are typically categorized as Bedrooms/Living Rooms in Table 6-1 with certain ventilation requirements. However, the eight levels of guest rooms on floors four through eleven of the hotel were granted a variance, which eliminated the usual numerical outdoor air condition. The designers received the variance because they justified using alternate means of introducing outside air to all the guest room spaces. Operable windows are used to directly ventilate the rooms. The other method employed involves drawing in supply air originally delivered to the corridors into the guest rooms via undercuts in the doors along the corridor.

The corridors on all the guest room floors were served by several roof-top units (RTU). These RTUs were not analyzed as part of this ventilation compliance check. Only the four AHUs that serve the ground and second floors are evaluated for this assignment. Also, the kitchen and many of the other spaces on the ground floor were not evaluated since they were served by the RTUs.

Since many of the spaces provided with supply air were not listed in Table 6-1 with required ventilation rates, values were estimated and applied to them. These spaces were also generally unoccupied spaces, so they only needed a ventilation requirement per unit area. Assumed values used are as follows:

Toilets: 0.25 cfm/sf
Mechanical Rooms: 0.25 cfm/sf
Electrical Rooms: 0.5 cfm/sf
Elevator Lobbies: 0.5 cfm/sf

Higher outdoor air rates were experimented with for all of the above spaces. However, if the quantity of air was increased too much, the zone primary outdoor air fraction would have exceeded 1.0. This would be physically impossible to construct in the building since the required amount of outdoor air exceeds the given quantity of supply air to the space. The values given above gave reasonable results, so that is why they were used.

The laundry areas and the housekeeping areas in the hotel were assumed to have similar occupancies and outdoor air rates similar to those of "coin-operated laundries" from Table 6-1. This was the closest approximate value available for these types of spaces, which was done as directed by General Note 6 from the footnotes of Table 6-1.

Since no design occupancy values (P_z) were available, an estimated value was determined from the given default occupancy densities provided in Table 6-1. This number was multiplied by the area of the space and divided by 1000 to calculate the design occupancy value for that space.

The design occupancies were calculated based on the default densities multiplied by the area for all of the office spaces in the building. However, if the calculated design occupancy for an office space was less than one, a minimum occupancy of one person per office was assumed.

In the pool lobby area outside of the swimming pool, it was assumed to have similar ventilation rates to those of the office spaces. This was because two adjacent bathrooms require supply air to be provided through door undercuts from the pool lobby area. The office space ventilation requirements were assumed for this space since they were often the most common rate used in buildings.

Two options were examined before choosing which method to use to calculate the breathing zone outdoor airflow (V_{bz}). The first option was to just use the given default occupancy densities and corresponding combined outdoor air rates provided in Table 6-1. This method was solely based on the number of occupants in a space.

Many of the spaces in the hotel do not have an occupancy condition listed, e.g. storage rooms, mechanical rooms, electrical rooms, corridors, toilet rooms, and elevator lobbies. This would require many more assumptions to be made about these spaces, which seemed unnecessary and inaccurate.

Therefore, the decision was made to use the outdoor airflow rates required per person (R_p) and the outdoor airflow rates required per unit area (R_a) from Table 6-1. The zone population (P_z) was assumed from the default occupancy densities, as described above. The zone areas were found by measuring all the dimensions of the spaces in the hotel.

A ventilation effectiveness (E_z) value of 1.0 was used for the zone air distribution effectiveness from Table 6-2. The "ceiling supply of cool air" was assumed to have perfect mixing conditions in all the spaces.

A diversity factor of 1.0 was assumed for all of the spaces in the building to be conservative. Most of the meeting/conference rooms could be occupied at the same time as all the office spaces. There would also be the possibility that all the meeting rooms could be used simultaneously for a large function, convention, or meeting. Therefore, to ensure a conservative design, no diversity was accounted for in the building.

The zone primary airflow (V_{pz}) was assumed to be equal to the airflow rate values given for the occupied minimum from the building floor plans.

The Maryland State Law prohibits smoking in all public buildings, so there was no concern over air quality affected by second-hand smoke in any areas inside the hotel. This most directly affects the bar areas, where smoking could have been an option, if it was not for the no smoking law.

Procedure

The procedure used for determining the outdoor air intake flow (V_{ot}) of all air-handling units followed the steps outlined in section 6.2 of ASHRAE 62.1-2004. These steps are described below, all the necessary equations are written out, and the variables are defined. The corresponding equation numbers given for each equation are listed beside them, as noted.

Please refer to the Assumptions section for any necessary assumptions related to any of the steps and values used here in the Procedure section.

Step 1:

Find the values for the zone floor areas (A_z) from the provided floor plans for each space in every zone. Also, determine the zone populations (P_z) for each space in every zone. Some spaces will have no (or zero) occupant densities provided.

If no occupant densities are given (as in this case), use the values for the default occupancy density from Table 6-1 to calculate the zone population (P_z). Please see the Assumptions section for more details.

Step 2:

Breathing Zone Outdoor Airflow (V_{bz}):

$$V_{bz} = R_p * P_z + R_a * A_z \qquad (6\text{-}1)$$

A_z = Zone floor area
P_z = Zone population
R_p = Outdoor airflow rate required per person
R_a = Outdoor airflow rate required per unit area

Find the values for the outdoor airflow rate required per person (R_p) and the outdoor airflow rate required per unit area (R_a) from Table 6-1.

Step 3:

Zone Air Distribution Effectiveness (E_z):

Find the value for the effectiveness from Table 6-2, based on the air distribution configuration of the spaces in the hotel.

Step 4:

Zone Outdoor Airflow (V_{oz}):

$$V_{oz} = V_{bz} / E_z \qquad (6\text{-}2)$$

Step 5:

Zone Primary Outdoor Air Fraction (Z_p):

$$Z_p = V_{oz} / V_{pz} \qquad (6\text{-}5)$$

V_{pz} = Zone primary airflow

This is for VAV systems, and in this case, the minimum expected primary airflow for design purposes.

Step 6:

System Ventilation Efficiency (E_v):

Find the value for the efficiency from Table 6-3 or Appendix A. If the efficiency is less than or equal to 0.55 Table 6-3 should be used. If the efficiency is more than 0.55, then use the procedure described in Appendix A.

See Appendix A below for the procedure and equations used from ASHRAE Standard 62.1-2004 – Appendix A. Then return to Step 7 for remainder of the procedure.

Appendix A:

Appendix A – Multiple-Zone Systems:

This information and equations listed below in Steps A through G are used to calculate the value for the system ventilation efficiency when E_v is greater than 0.55 and Table 6-3 cannot be used.

Step A:

Diversity Factor (D):

$D = P_s / (\Sigma_{all\ zones} P_z)$

P_s = System population

The diversity factor is the ratio of the system population to the sum of the zone populations.

Find from the assumed diversity among the spaces. Please see Assumptions for more details.

Step B:

Uncorrected Outdoor Air Intake (V_{ou}):

$V_{ou} = D*\Sigma R_p*P_z + \Sigma R_a*A_z$ (6-6)

The uncorrected outdoor air intake is adjusted for diversity, but it is uncorrected for ventilation efficiency.

The uncorrected outdoor air intake values are equal to the zone outdoor airflow (V_{oz}) with the zone air distribution effectiveness (E_z) equal to 1.0, which is just the breathing zone outdoor airflow (V_{bz}) for this case.

Step C:

System Primary Airflow (V_{ps}):

$V_{ps} = \Sigma V_{pz}$

The sum of the zone primary airflows is the total supply air from the air-handling unit to all the spaces that it serves.

Step D:

Average Outdoor Air Fraction (X_s):

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

Step E:

Discharge Outdoor Air Fraction (Z_d):

$Z_d = V_{oz} / V_{dz}$

For VAV systems, the zone discharge airflow (V_{dz}) is the amount of supply air and recirculated air provided to the space. In this case it is equal to just the supply air of the space.

Step F:

Single Supply Systems:

$E_{vz} = 1 + X_s – Z_d$ (A-1)

This is used where all the ventilation air is a mixture of the outdoor and recirculated air from a single location, e.g. Reheat, Single-Duct VAV, Single-Fan Dual-Duct, and Multizone spaces.

Step G:

System Ventilation Efficiency (E_v):

E_v = minimum (E_{vz}) (A-3)

After determining the the system ventilation efficiency, return to Step 7 above and follow the rest of the procedure.

Step 7:

Occupant Diversity (D):

$D = P_s / (\Sigma_{\text{all zones}} P_z)$

P_s = System population

The diversity factor is the ratio of the system population to the sum of the zone populations.

Step 8:

Uncorrected Outdoor Air Intake (V_{ou}):

$$V_{ou} = D*\Sigma R_p*P_z + \Sigma R_a*A_z \qquad (6\text{-}6)$$

The uncorrected outdoor air intake is adjusted for diversity, but it is uncorrected for ventilation efficiency.

Step 9:

Design Outdoor Air Intake Flow (V_{ot}):

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

Calculations

All of the calculations to find the design outdoor air intake flow (V_{ot}) followed the same steps in the procedure. Please refer to the Procedure section for all equations and variables used in the calculations. Also, please refer to the Assumptions section for any of the necessary assumptions made.

After completing all the calculations for all the spaces, it was observed that three out of the four AHUs had zone primary outdoor air fractions (Z_p) that were greater than 0.55. Thus, the system efficiency (Ev) was found directly from Table 6-3 only for AHU-1. However, AHU-2, AHU-3, and AHU-4 had Z_p values greater than 0.55, which means that Appendix A was used to calculate the E_v for those three systems. AHU-2 was chosen to demonstrate the procedure described previously and show the basic calculations.

The critical zone for AHU-2 was the Coffee Bar, which was room 105 on the ground floor of the building. This bar area was provided with 750 cfm of supply air for an area of 2008 square feet.

The calculations in the following steps were for finding the design outdoor air intake flow (V_{ot}) for AHU-2:

Step 1:

A_z = 2008 sf
P_z = (46 people/1000 sf)*2008 sf = 65 people

Step 2:

R_p = 7.5 cfm/person
R_a = 0.18 cfm/sf
A_z = 2008 sf
P_z = 46 people

$V_{bz} = R_p*P_z+R_a*A_z$ = (7.5 cfm/person)*(46 people) + (0.18 cfm/sf)*(2008 sf)
V_{bz} = 747 cfm

Step 3:

E_z = 1.0 (from Table 6-2, for ceiling supply of cool air)

Step 4:

$V_{oz} = V_{bz} / E_z$ = 747 cfm / 1.0
V_{oz} = 747 cfm

Step 5:

$Z_p = V_{oz} / V_{pz}$ = 747 cfm / 750 cfm
Z_p = 0.996 → 1.0
Max. Z_p = 1.0

Step 6:

Must follow Appendix A procedure to find E_v since Z_p = 1.0 > 0.55

Step A:

$D = P_s / (\Sigma_{all\ zones} P_z)$ and $P_s = \Sigma_{all\ zones} P_z$ → D = 1.0

Step B:

$V_{ou} = D*\Sigma R_p*P_z + \Sigma R_a*A_z = (1.0)*\Sigma R_p*P_z + \Sigma R_a*A_z$
$V_{ou} = \Sigma V_{oz}$
V_{ou} = 9365 cfm

Step C:

$V_{ps} = \Sigma V_{pz}$
V_{ps} = 15,960 cfm

Step D:

$X_s = V_{ou} / V_{ps}$ = 9365 cfm / 15,960 cfm
X_s = 0.587

Step E:

$Z_d = V_{oz} / V_{dz}$ = 747 cfm / 750 cfm
Z_d = 0.996

Step F:

$E_{vz} = 1 + X_s – Z_d = 1 + 0.587 – 0.996$
E_{vz} = 0.591 → 0.59

Step G:

E_v = minimum (E_{vz})
E_v = minimum (0.59) = 0.59

Step 7:

$D = P_s / (\Sigma_{all\ zones} P_z)$ and $P_s = \Sigma_{all\ zones} P_z \rightarrow D = 1.0$

Step 8:

$V_{ou} = D*\Sigma R_p*P_z + \Sigma R_a*A_z = (1.0)*\Sigma R_p*P_z + \Sigma R_a*A_z$
$V_{ou} = \Sigma V_{oz}$
$V_{ou} = 9365$ cfm

Step 9:

$V_{ot} = V_{ou} / E_v = 9365$ cfm $/ 0.59$
$V_{ot} = 15{,}873$ cfm

AHU-2 Summary:

The total outside airflow computed was 9365 cfm and the design outdoor air intake flow was 15,873 cfm from the calculations. The actual amount for the unit minimum outdoor air was 11,500 cfm, and the unit total supply air was 23,000 cfm for AHU-2 from the AHU schedules in the plans. Therefore, since the actual amount of outdoor air scheduled was less than the required outdoor air quantity, AHU-2 did not comply with ASHRAE Standard 62.1-2004.

Discussion

AHU Information:

All AHUs in the hotel were designed with VAV all-air systems. The four AHUs served the ground and second floors of the building. The third through the eleventh floors were all served strictly by roof-top units (RTU). Several other RTUs were used to supply air to the ground and second floors. However, only the four AHUs were used in the compliance check with ASHRAE Standard 62.1-2004.

AHU-1:

AHU-1 served the ground floor of the building with 25,000 cfm total supply air and 16,000 cfm minimum outdoor air. The calculated total outdoor airflow was 6395 cfm, and the design outdoor air intake flow was 9136 cfm. Since the actual unit outdoor airflow was greater than the required outdoor airflow, AHU-1 complied with ASHRAE Standard 62.1-2004.

AHU-2:

AHU-2 served the ground floor of the building with 23,000 cfm total supply air and 11,500 cfm minimum outdoor air. The calculated total outdoor airflow was 9365 cfm, and the design outdoor air intake flow was 15,873 cfm. Since the actual unit outdoor airflow was less than the required outdoor airflow, AHU-2 did not comply with ASHRAE Standard 62.1-2004.

AHU-3:

AHU-3 served the second floor of the building with 8600 cfm total supply air and 4300 cfm minimum outdoor air. The calculated total outdoor airflow was 2957 cfm, and the design outdoor air intake flow was 5280 cfm. Since the actual unit outdoor airflow was greater than the required outdoor airflow, AHU-3 complied with ASHRAE Standard 62.1-2004.

AHU-4:

AHU-4 served the ground floor of the building with 7500 cfm total supply air and 2000 cfm minimum outdoor air. The calculated total outdoor airflow was 2087 cfm, and the design outdoor air intake flow was 3478 cfm. Since the actual unit outdoor airflow was less than the required outdoor airflow, AHU-4 did not comply with ASHRAE Standard 62.1-2004.

Comparison of nominal outside air and required outside air:

The unit minimum outdoor air quantity for AHU-1 was greater than the required design outdoor air intake flow. However, the other three air handling units, AHU-2, AHU-3, and AHU-4, all had unit minimum outdoor air quantities less than the required outdoor air intake flows. As a result, only AHU-1was compliant with the minimum outside air requirements of ASHRAE Standard 62.1-2004, but AHU-2, AHU-3, and AHU-4 were not compliant.

There could be many possible reasons that there was a significant difference between the required outdoor airflow and the actual amount of outdoor air given in the schedules. The main reason for this was because there were no design occupancy conditions given for any of the spaces or zones. Therefore, an assumption was made that the default occupancy densities could be used to calculate the design occupancy conditions. Even though this was the only available option besides guessing occupancy values, it was still a very inaccurate approximation.

The comparison of all the amounts of nominal outside air and the required outside quantities can be found in Appendix F. By observation, it can be seen that none of the total outdoor airflows or design outdoor air intake flows were very close to the given values used in the Hilton Hotel at BWI Airport schedules and plans.

Appendix Information:

The “Zone Number” columns in the tables were listed as “X-Y.” The “X” value referred to the air-handling unit (AHU) number, which ranged from 1 to 4. The “Y” value referred to a designated number for the variable air volume (VAV) boxes from each AHU. This designation was assigned to easily identify each VAV box zone for the building.

The VAV boxes were listed according to the space or spaces to which they provide supply air. Many VAV boxes served only one space, while some VAV boxes served multiple spaces in one zone. Other spaces had more than one VAV box providing supply air, and the space characteristics and outside air requirements were listed for the entire space, not per VAV box.

The information listed in Appendix A – Space Characteristics and Appendix B – VAV Box Characteristics was basically the same, except for the way the information was organized. This was done to show where the information came from for every VAV box zone. This information included the zone numbers, space names, functions/uses, VAV boxes, occupied maximum

airflow rates, occupied minimum airflow rates, space areas, and design occupancies.

Similarly, the information in Appendix C – Space Outdoor Air Requirements and Appendix D – Zone Outdoor Air Requirements was listed for the same reasons. This allowed for easy comparison of the VAV boxes and the spaces that they served in the building. The outdoor air requirements were determined from the assumed designed occupancies, people outdoor air rates, and area outdoor air rates.

In Appendix E – Zone Primary Outdoor Air Fractions, the "*" denoted the critical space for each AHU with the maximum zone primary airflow. The outdoor air requirements found in Appendices A and B were used to find the zone outdoor airflows, zone primary outdoor airflows, zone primary outdoor air fractions, and the zone maximum outdoor air fractions. These calculated values from the critical spaces were used to determine system ventilation efficiency and the design outdoor air intake flow.

Please see the above comparison for the explanation of the values found in Appendix F – AHU Outdoor Air Comparisons. Summaries of the total outdoor airflow, required design outdoor air intake flow, unit minimum outdoor air, and unit total supply air were listed.

Procedure Comparison

Ventilation Rate Procedure compared to Indoor Air Quality Procedure

ASHRAE Standard 62.1-2004 includes two different methods for determining compliance with the standard. The first method is the Ventilation Rate Procedure (VRP), which is a prescriptive means for finding the required outside air rates. The other method is the Indoor Air Quality Procedure (IAQP), and it is more of a performance-based requirement. Both methods are compared with their major differences and applicability.

Ventilation Rate Procedure

The VRP is the method used for calculating the required amounts of outside air for all of the air-handling units in this report. It has a very systematic procedure with a series of equations for find the outside air intake rates. This process can be followed easily if all the floor areas, uses, and occupancies of the spaces are known. The Standard takes into account general contaminant concentrations in various types of spaces, which are listed in Table 6-1 of Standard 62.1-2004. The table provides values based on occupancy levels as well as the floor area of the spaces. The occupancy levels provide a ventilation rate to dilute an average amount of carbon dioxide based on the function and use of the space. The other ventilation rate takes into account the contaminants found in the building materials of certain types of spaces.

Indoor Air Quality Procedure

The IAQP method specifies various types of contaminants and acceptable levels for those impurities in certain types of spaces. The procedure analyzes the concentration of the contaminants in the spaces and gives target values for these concentrations. The IAQP also takes into account several methods used to reduce the concentration of the contaminants. One method is to choose building materials with smaller amounts of impurities that can be released into the air. The other method is using air cleaning devices that remove these impurities. It must be shown that using these methods or devices does result in lower contaminant concentration levels in the building.

Comparison

The VRP is a more general method for determining acceptable ventilation rates than the IAQP. The IAQP analyzes certain air contaminants and not just the size, occupancy, and type of space that the air is in like the VRP. The VRP can be more widely used because the steps can be followed at the beginning of a project before specific building materials are known. The IAQP would be more beneficial in spaces where the target contaminant levels are known or required and certain air impurities must be analyzed.

Appendix A – Space Characteristics

AHU-1

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
1-1	Meeting Room 'G'	Conference/Meeting	(2) VV-8	4500	4500	3365	168
1-2	Meeting Room 'F'	Conference/Meeting	(2) VV-7	3200	3200	2479	124
1-3	Meeting Room 'C'	Conference/Meeting	VV-7	1600	1600	1235	62
1-4	Meeting Room 'E'	Conference/Meeting	VV-7	1600	1600	1164	58
1-5	Meeting Room 'B'	Conference/Meeting	VV-6	1500	1050	608	30
1-6	Meeting Room 'A'	Conference/Meeting	VV-6	1500	1050	655	33
1-7	Pre-Function Area	Lobby/Pre-function	(5) VV-6, VV-6	9200	2900	3592	431

AHU-2

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
2-1	Restaurant	Restaurant Dining Rooms	(2) VV-6, (2) VV-8	7200	4695	4279	300
–	Women's Restroom	Toilets	–	100	–	181	0
–	Men's Restroom	Toilets	–	100	–	166	0
2-2	–	Toilets	VV-1	200	200	347	0
2-3	Electrical Room	Service Area	VV-5	900	900	235	0
2-4	Bar	Bar	VV-7	1800	450	1373	26
2-5	Coffee Bar	Bar	VV-8	2700	750	1422	65
2-6	Lobby Seating 'A'	Lobby/Pre-function	(2) VV-8	5520	3000	2008	241
–	Switch Board	Telephone/Data Entry	–	100	–	80	5
–	Accounting/Audit	Office Space	–	100	–	64	1
–	Computer Room	Office Space	–	100	–	45	1
–	Front Desk Work Area	Office Space	–	150	–	235	1
–	Service Corridor	Corridor	–	145	–	217	0
–	Front Office Manager	Office Space	–	100	–	88	1
–	Sundries	Office Space	–	100	–	108	1
–	Luggage Storage	Storage Room	–	100	–	141	0
2-7	–	–	VV-5	895	840	978	10
–	Main Lobby	Lobby/Pre-function	–	2040	–	2138	257
–	Lobby Seating 'B'	Lobby/Pre-function	–	200	–	246	30
–	Elevator Lobby	Service Area	–	400	–	185	0
–	Front Desk	Office Space	–	300	–	336	2
2-8	–	–	VV-8	2940	2400	2905	288
–	Corridor	Corridor	–	750	–	1585	0
–	Catering Manager	Office Space	–	200	–	154	1
–	Coat Room	Storage Room	–	100	–	228	0
–	Valet Parking	Office Space	–	125	–	88	1
–	FCR	Storage Room	–	125	–	82	0
2-9	–	–	VV-7	1300	1300	2137	2
–	Telephones	Lobby/Pre-function	–	200	–	409	49
–	Women's Restroom	Toilets	–	725	–	593	0
–	Men's Restroom	Toilets	–	500	–	331	0
2-10	–	–	VV-6	1425	1425	1333	49

AHU-3

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
	Meeting Room	Conference/Meeting	–	1050	–	636	32
	Corridor	Corridor	–	100	–	127	0
3-1	–	–	VV-6	1150	1150	763	32
3-2	Meeting Room	Conference/Meeting	VV-6	1050	1050	626	31
3-3	Board Room	Conference/Meeting	VV-6	1050	1050	626	31
3-4	Mechanical Room	Service Area	VV-1	300	180	442	0
	Sales Department	Office Space	–	450	–	355	2
	Director of Sales	Office Space	–	300	–	155	1
3-5	–	–	VV-5	750	570	510	3
	Supply Room	Storage Room	–	75	–	58	0
	Office Corridor	Corridor	–	80	–	206	0
	Work Room	Office Space	–	225	–	55	1
3-6	–	–	VV-1	380	235	319	1
	Asst. General Manager	Office Space	–	300	–	155	1
	General Manager	Office Space	–	300	–	161	1
	Executive Assistant	Office Space	–	450	–	389	2
3-7	–	–	VV-6	1050	630	705	4
	Pantry	Storage Room	–	100	–	145	0
	Business Center	Office Space	–	145	–	153	1
	Corridor	Corridor	–	100	–	127	0
	Women's Restroom	Toilets	–	75	–	154	0
	Men's Restroom	Toilets	–	75	–	150	0
	Elevator Lobby	Service Area	–	550	–	202	0
3-8	–	–	VV-6	1215	1000	931	1
	Pool Lobby	Service Area	–	300	–	530	3
	Pool Equipment Room	Storage Room	–	400	–	227	0
3-9	–	–	VV-4	700	400	757	3
3-10	Health Club	Health Club/Aerobics Room	VV-8	2400	1800	1665	67
3-11	Elec./Comm. Room	Service Area	VV-1	200	120	110	0
3-12	Corridor	Corridor	VV-1	300	180	968	0

AHU-4

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
4-1	Electrical Room	Service Area	VV-3	600	360	216	0
	AV Storage	Storage Room	–	75	–	110	0
	Banquet Set Up Manager	Office Space	–	100	–	135	1
	Service Corridor	Corridor	–	200	–	408	0
	Banquet Specialty Storage	Storage Room	–	350	–	621	0
	Table and Chair Storage	Storage Room	–	450	–	1081	0
4-2	–	–	VV-6	1175	705	2355	1
	Male Empl. Lockers/Toilets	Toilets	–	500	–	443	0
	Female Empl. Lockers/Toilets	Toilets	–	500	–	489	0
	Banquet Pantry	Storage Room	–	200	–	255	0
	Service Corridor	Corridor	–	300	–	991	0
	Mini-Bar Storage	Storage Room	–	150	–	223	0
	Clean Plate and Glass Storage	Storage Room	–	300	–	477	0
4-3	–	–	VV-6	1950	900	2878	0
	Service Corridor	Corridor	–	100	–	353	0
	Purchasing Office	Office Space	–	100	–	94	1
	Purchasing Manager	Office Space	–	100	–	96	1
	F and B Manager	Office Space	–	125	–	101	1
	General Storage	Storage Room	–	500	–	1227	0
4-4	–	–	VV-5	925	400	1871	3
	Service Corridor	Corridor	–	450	–	1209	0
	Security Office	Office Space	–	180	–	167	1
	Receiving	Shipping/Receiving	–	400	–	168	0
4-5	–	–	VV-4	1030	400	1544	1
4-6	Employee Cafeteria	Cafeteria	VV-6	1400	1400	593	59
	Service Corridor	Corridor	–	100	–	240	0
	Personnel Room	Office Space	–	400	–	417	2
	Training Manager	Office Space	–	250	–	142	1
	Personnel Manager	Office Space	–	300	–	148	1
4-7	–	–	VV-6	1050	500	1540	4

Appendix B – VAV Box Characteristics

AHU-1

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
1-1	Meeting Room 'G'	Conference/Meeting	(2) VV-8	4500	4500	3365	168
1-2	Meeting Room 'F'	Conference/Meeting	(2) VV-7	3200	3200	2479	124
1-3	Meeting Room 'C'	Conference/Meeting	VV-7	1600	1600	1235	62
1-4	Meeting Room 'E'	Conference/Meeting	VV-7	1600	1600	1164	58
1-5	Meeting Room 'B'	Conference/Meeting	VV-6	1500	1050	608	30
1-6	Meeting Room 'A'	Conference/Meeting	VV-6	1500	1050	655	33
1-7	Pre-Function Area	Lobby/Pre-function	(5) VV-6, VV-6	9200	2900	3592	431

AHU-2

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
2-1	Restaurant	Restaurant Dining Rooms	(2) VV-6, (2) VV-8	7200	4695	4279	300
2-2	–	Toilets	VV-1	200	200	347	0
2-3	Electrical Room	Service Area	VV-5	900	900	235	0
2-4	Bar	Bar	VV-7	1800	450	1373	26
2-5	Coffee Bar	Bar	VV-8	2700	750	1422	65
2-6	Lobby Seating 'A'	Lobby/Pre-function	(2) VV-8	5520	3000	2008	241
2-7	–	Office Space	VV-5	895	840	978	10
2-8	–	Lobby/Pre-function	VV-8	2940	2400	2905	288
2-9	–	Office Space	VV-7	1300	1300	2137	2
2-10	–	Lobby/Pre-function	VV-6	1425	1425	1333	49

AHU-3

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
3-1	–	Conference/Meeting	VV-6	1150	1150	763	32
3-2	Meeting Room	Conference/Meeting	VV-6	1050	1050	626	31
3-3	Board Room	Conference/Meeting	VV-6	1050	1050	626	31
3-4	Mechanical Room	Service Area	VV-1	300	180	442	0
3-5	–	Office Space	VV-5	750	570	510	3
3-6	–	Storage Room	VV-1	380	235	319	1
3-7	–	Office Space	VV-6	1050	630	705	4
3-8	–	Service Area	VV-6	1215	1000	931	1
3-9	–	Storage Room	VV-4	700	400	757	3
3-10	Health Club	Health Club/Aerobics Room	VV-8	2400	1800	1665	67
3-11	Elec./Comm. Room	Service Area	VV-1	200	120	110	0
3-12	Corridor	Corridor	VV-1	300	180	968	0

AHU-4

Zone No.	Space Name	Function / Use	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Space Area A_z (sf)	Design Occ., P_z (people)
4-1	Electrical Room	Service Area	VV-3	600	360	216	0
4-2	–	Storage Room	VV-6	1175	705	2355	1
4-3	–	Toilets	VV-6	1950	900	2878	0
4-4	–	Office Space	VV-5	925	400	1871	3
4-5	–	Shipping/Receiving	VV-4	1030	400	1544	1
4-6	Employee Cafeteria	Cafeteria	VV-6	1400	1400	593	59
4-7	–	Office Space	VV-6	1050	500	1540	4

Appendix C – Space Outdoor Air Requirements

AHU-1

Zone No.	Space Name	Function / Use	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
1-1	Meeting Room 'G'	Conference/Meeting	(2) VV-8	3365	168	5	0.06	50	1043	1043
1-2	Meeting Room 'F'	Conference/Meeting	(2) VV-7	2479	124	5	0.06	50	768	768
1-3	Meeting Room 'C'	Conference/Meeting	VV-7	1235	62	5	0.06	50	383	383
1-4	Meeting Room 'E'	Conference/Meeting	VV-7	1164	58	5	0.06	50	361	361
1-5	Meeting Room 'B'	Conference/Meeting	VV-6	608	30	5	0.06	50	188	188
1-6	Meeting Room 'A'	Conference/Meeting	VV-6	655	33	5	0.06	50	203	203
1-7	Pre-Function Area	Lobby/Pre-function	(5) VV-6, VV-6	3592	431	7.5	0.06	120	3448	3448

AHU-2

Zone No.	Space Name	Function / Use	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
2-1	Restaurant	Restaurant Dining Rooms	(2) VV-6, (2) VV-8	4279	300	7.5	0.18	70	3017	3017
–	Women's Restroom	Toilets	–	181	0	0	0.25	0	–	–
–	Men's Restroom	Toilets	–	166	0	0	0.25	0	–	–
2-2	–	Toilets	VV-1	347	0	0	0.25	–	87	87
2-3	Electrical Room	Service Area	VV-5	235	0	0	0.5	0	118	118
2-4	Bar	Bar	VV-7	1373	26	7.5	0.18	19	443	443
2-5	Coffee Bar	Bar	VV-8	1422	65	7.5	0.18	46	747	747
2-6	Lobby Seating 'A'	Lobby/Pre-function	(2) VV-8	2008	241	7.5	0.06	120	1928	1928
–	Switch Board	Telephone/Data Entry	–	80	5	5	0.06	60	–	–
–	Accounting/Audit	Office Space	–	64	1	5	0.06	5	–	–
–	Computer Room	Office Space	–	45	1	5	0.06	5	–	–
–	Front Desk Work Area	Office Space	–	235	1	5	0.06	5	–	–
–	Service Corridor	Corridor	–	217	0	0	0.06	0	–	–
–	Front Office Manager	Office Space	–	88	1	5	0.06	5	–	–
–	Sundries	Office Space	–	108	1	5	0.06	5	–	–
–	Luggage Storage	Storage Room	–	141	0	0	0.12	0	–	–
2-7	–	–	VV-5	978	10	5	0.06	–	109	109
–	Main Lobby	Lobby/Pre-function	–	2138	257	7.5	0.06	120	–	–
–	Lobby Seating 'B'	Lobby/Pre-function	–	246	30	7.5	0.06	120	–	–
–	Elevator Lobby	Service Area	–	185	0	0	0.5	0	–	–
–	Front Desk	Office Space	–	336	2	5	0.06	5	–	–
2-8	–	–	VV-8	2905	288	7.5	0.06	–	2333	2333
–	Corridor	Corridor	–	1585	0	0	0.06	0	–	–
–	Catering Manager	Office Space	–	154	1	5	0.06	5	–	–
–	Coat Room	Storage Room	–	228	0	0	0.12	0	–	–
–	Valet Parking	Office Space	–	88	1	5	0.06	5	–	–
–	FCR	Storage Room	–	82	0	0	0.12	0	–	–
2-9	–	–	VV-7	2137	2	5	0.06	–	138	138
–	Telephones	Lobby/Pre-function	–	409	49	7.5	0.06	120	–	–
–	Women's Restroom	Toilets	–	593	0	0	0.25	0	–	–
–	Men's Restroom	Toilets	–	331	0	0	0.25	0	–	–
2-10	–	–	VV-6	1333	49	7.5	0.06	–	448	448

AHU-3

Zone No.	Space Name	Function / Use	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
	Meeting Room	Conference/Meeting	–	636	32	5	0.06	50	–	–
	Corridor	Corridor	–	127	0	0	0.06	0	–	–
3-1	–	–	VV-6	763	32	5	0.06	–	205	205
3-2	Meeting Room	Conference/Meeting	VV-6	626	31	5	0.06	50	194	194
3-3	Board Room	Conference/Meeting	VV-6	626	31	5	0.06	50	194	194
3-4	Mechanical Room	Service Area	VV-1	442	0	0	0.25	0	111	111
	Sales Department	Office Space	–	365	2	5	0.06	5	–	–
	Director of Sales	Office Space	–	155	1	5	0.06	5	–	–
3-5	–	–	VV-5	510	3	5	0.06	–	44	44
	Supply Room	Storage Room	–	58	0	0	0.12	0	–	–
	Office Corridor	Corridor	–	206	0	0	0.06	0	–	–
	Work Room	Office Space	–	55	1	5	0.06	5	–	–
3-6	–	–	VV-1	319	1	0	0.12	–	38	38
	Asst. General Manager	Office Space	–	155	1	5	0.06	5	–	–
	General Manager	Office Space	–	161	1	5	0.06	5	–	–
	Executive Assistant	Office Space	–	389	2	5	0.06	5	–	–
3-7	–	–	VV-6	705	4	5	0.06	–	62	62
	Pantry	Storage Room	–	145	0	0	0.12	0	–	–
	Business Center	Office Space	–	153	1	5	0.06	5	–	–
	Corridor	Corridor	–	127	0	0	0.06	–	8	8
	Women's Restroom	Toilets	–	154	0	0	0.25	0	–	–
	Men's Restroom	Toilets	–	150	0	0	0.25	0	–	–
	Elevator Lobby	Service Area	–	202	0	0	0.5	0	–	–
3-8	–	–	VV-6	931	1	0	0.5	–	466	466
	Pod Lobby	Service Area	–	530	3	5	0.06	5	–	–
	Pod Equipment Room	Storage Room	–	227	0	0	0.12	0	–	–
3-9	–	–	VV-4	757	3	0	0.12	–	91	91
3-10	Health Club	Health Club/Aerobics Room	VV-8	1665	67	20	0.06	40	1440	1440
3-11	Elec./Comm Room	Service Area	VV-1	110	0	0	0.5	0	55	55
3-12	Corridor	Corridor	VV-1	968	0	0	0.06	0	58	58

AHU-4

Zone No.	Space Name	Function / Use	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
4-1	Electrical Room	Service Area	VV-3	216	0	0	0.5	0	108	108
	AV Storage	Storage Room	–	110	0	0	0.12	0	–	–
	Banquet Set Up Manager	Office Space	–	135	1	5	0.06	5	–	–
	Service Corridor	Corridor	–	408	0	0	0.06	0	–	–
	Banquet Specialty Storage	Storage Room	–	621	0	0	0.12	0	–	–
	Table and Chair Storage	Storage Room	–	1081	0	0	0.12	0	–	–
4-2	–	–	VV-6	2355	1	0	0.12	–	283	283
	Male Empl. Lockers/Toilets	Toilets	–	443	0	0	0.25	0	–	–
	Female Empl. Lockers/Toilets	Toilets	–	489	0	0	0.25	0	–	–
	Banquet Pantry	Storage Room	–	255	0	0	0.12	0	–	–
	Service Corridor	Corridor	–	991	0	0	0.06	0	–	–
	Mini-Bar Storage	Storage Room	–	223	0	0	0.12	0	–	–
	Clean Plate and Glass Storage	Storage Room	–	477	0	0	0.12	0	–	–
4-3	–	–	VV-6	2878	0	0	0.25	–	720	720
	Service Corridor	Corridor	–	363	0	0	0.06	0	–	–
	Purchasing Office	Office Space	–	94	1	5	0.06	5	–	–
	Purchasing Manager	Office Space	–	96	1	5	0.06	5	–	–
	F and B Manager	Office Space	–	101	1	5	0.06	5	–	–
	General Storage	Storage Room	–	1227	0	0	0.12	0	–	–
4-4	–	–	VV-5	1871	3	5	0.06	–	127	127
	Service Corridor	Corridor	–	1209	0	0	0.06	0	–	–
	Security Office	Office Space	–	167	1	5	0.06	5	–	–
	Receiving	Shipping/Receiving	–	168	0	0	0.12	0	–	–
4-5	–	–	VV-4	1544	1	0	0.12	–	185	185
4-6	Employee Cafeteria	Cafeteria	VV-6	593	59	7.5	0.18	100	551	551
	Service Corridor	Corridor	–	240	0	0	0.06	0	–	–
	Personnel Room	Office Space	–	417	2	5	0.06	5	–	–
	Training Manager	Office Space	–	142	1	5	0.06	5	–	–
	Personnel Manager	Office Space	–	148	1	5	0.06	5	–	–
4-7	–	–	VV-6	1540	4	5	0.06	–	113	113

Appendix D – Zone Outdoor Air Requirements

AHU-1

Zone No.	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
1-1	(2) VV-8	3365	168	5	0.06	50	1043	1043
1-2	(2) VV-7	2479	124	5	0.06	50	768	768
1-3	VV-7	1235	62	5	0.06	50	383	383
1-4	VV-7	1164	58	5	0.06	50	361	361
1-5	VV-6	608	30	5	0.06	50	188	188
1-6	VV-6	655	33	5	0.06	50	203	203
1-7	(5) VV-6, VV-6	3592	431	7.5	0.06	120	3448	3448

AHU-2

Zone No.	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
2-1	(2) VV-6, (2) VV-8	4279	300	8	0.18	70	3017	3017
2-2	VV-1	347	0	0	0.25	--	87	87
2-3	VV-5	235	0	0	0.5	0	118	118
2-4	VV-7	1373	26	8	0.18	19	443	443
2-5	VV-8	1422	65	8	0.18	46	747	747
2-6	(2) VV-8	2008	241	8	0.06	120	1928	1928
2-7	VV-5	978	10	5	0.06	--	109	109
2-8	VV-8	2905	288	8	0.06	--	2333	2333
2-9	VV-7	2137	2	5	0.06	--	138	138
2-10	VV-6	1333	49	8	0.06	--	448	448

AHU-3

Zone No.	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
3-1	VV-6	763	32	5	0.06	--	205	205
3-2	VV-6	626	31	5	0.06	50	194	194
3-3	VV-6	626	31	5	0.06	50	194	194
3-4	VV-1	442	0	0	0.25	0	111	111
3-5	VV-5	510	3	5	0.06	--	44	44
3-6	VV-1	319	1	0	0.12	--	38	38
3-7	VV-6	705	4	5	0.06	--	62	62
3-8	VV-6	931	1	0	0.5	--	466	466
3-9	VV-4	757	3	0	0.12	--	91	91
3-10	VV-8	1665	67	20	0.06	40	1440	1440
3-11	VV-1	110	0	0	0.5	0	55	55
3-12	VV-1	968	0	0	0.06	0	58	58

AHU-4

Zone No.	VAV Box(es)	Space Area A_z (sf)	Design Occ., P_z (people)	People Outdoor Air Rate, R_p (cfm/person)	Area Outdoor Air Rate Ra (cfm/sf)	Default Occ. Density (#/1000 sf)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)
4-1	VV-3	216	0	0	0.5	0	108	108
4-2	VV-6	2355	1	0	0.12	--	283	283
4-3	VV-6	2878	0	0	0.25	--	720	720
4-4	VV-5	1871	3	5	0.06	--	127	127
4-5	VV-4	1544	1	0	0.12	--	185	185
4-6	VV-6	593	59	7.5	0.18	100	551	551
4-7	VV-6	1540	4	5	0.06	--	113	113

Appendix E – Zone Primary Outdoor Air Fractions

AHU-1

Zone No.	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)	Zone Primary Airflow V_{pz} (cfm)	Zone Primary Outdoor Air Fraction, Z_p	Zone Max., Z_p
1-1	(2) VV-8	4500	4500	1043	1043	4500	0.23	0.37
1-2	(2) VV-7	3200	3200	768	768	3200	0.24	--
1-3	VV-7	1600	1600	383	383	1600	0.24	--
1-4	VV-7	1600	1600	361	361	1600	0.23	--
1-5	VV-6	1500	1050	188	188	1500	0.13	--
1-6	VV-6	1500	1050	203	203	1500	0.14	--
1-7	(5) VV-6, VV-6	9200	2900	3448	3448	9200	0.37	*

AHU-2

Zone No.	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)	Zone Primary Airflow V_{pz} (cfm)	Zone Primary Outdoor Air Fraction, Z_p	Zone Max., Z_p
2-1	(2) VV-6, (2) VV-8	7200	4695	3017	3017	4695	0.64	1.00
2-2	VV-1	200	200	87	87	200	0.43	--
2-3	VV-5	900	900	118	118	900	0.13	--
2-4	VV-7	1800	450	443	443	450	0.98	--
2-5	VV-8	2700	750	747	747	750	1.00	*
2-6	(2) VV-8	5520	3000	1928	1928	3000	0.64	--
2-7	VV-5	895	840	109	109	840	0.13	--
2-8	VV-8	2940	2400	2333	2333	2400	0.97	--
2-9	VV-7	1300	1300	138	138	1300	0.11	--
2-10	VV-6	1425	1425	448	448	1425	0.31	--

AHU-3

Zone No.	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)	Zone Primary Airflow V_{pz} (cfm)	Zone Primary Outdoor Air Fraction, Z_p	Zone Max., Z_p
3-1	VV-6	1150	1150	205	205	1150	0.18	0.80
3-2	VV-6	1050	1050	194	194	1050	0.18	--
3-3	VV-6	1050	1050	194	194	1050	0.18	--
3-4	VV-1	300	180	111	111	180	0.61	--
3-5	VV-5	750	570	44	44	570	0.08	--
3-6	VV-1	380	235	38	38	235	0.16	--
3-7	VV-6	1050	630	62	62	630	0.10	--
3-8	VV-6	1215	1000	466	466	1000	0.47	--
3-9	VV-4	700	400	91	91	400	0.23	--
3-10	VV-8	2400	1800	1440	1440	1800	0.80	*
3-11	VV-1	200	120	55	55	120	0.46	--
3-12	VV-1	300	180	58	58	180	0.32	--

AHU-4

Zone No.	VAV Box(es)	Occupied Max. (cfm)	Occupied Min. (cfm)	Breathing Zone Outdoor Airflow V_{bz} (cfm)	Zone Outdoor Airflow V_{oz} (cfm)	Zone Primary Airflow V_{pz} (cfm)	Zone Primary Outdoor Air Fraction, Z_p	Zone Max., Z_p
4-1	VV-3	600	360	108	108	360	0.30	0.80
4-2	VV-6	1175	705	283	283	705	0.40	--
4-3	VV-6	1950	900	720	720	900	0.80	*
4-4	VV-5	925	400	127	127	400	0.32	--
4-5	VV-4	1030	400	185	185	400	0.46	--
4-6	VV-6	1400	1400	551	551	1400	0.39	--
4-7	VV-6	1050	500	113	113	500	0.23	--

Appendix F – AHU Outdoor Air Comparisons

Unit	Zone Max. Zp	System Ventilation Efficiency, E_v	Uncorrected Outdoor Air Intake V_{ou} (cfm)	Total Outdoor Airflow ΣV_{oz} (cfm)	Design Outdoor Air Intake Flow V_{ot} (cfm)	Unit Min. Outdoor Air (cfm)	Unit Total Supply Air (cfm)
AHU-1	0.37	0.70	6395	6395	9136	16,000	25,000
AHU-2	1.00	0.59	9365	9365	15,873	11,500	23,000
AHU-3	0.80	0.56	2957	2957	5280	4300	8600
AHU-4	0.80	0.60	2087	2087	3478	2000	7500

References

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

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