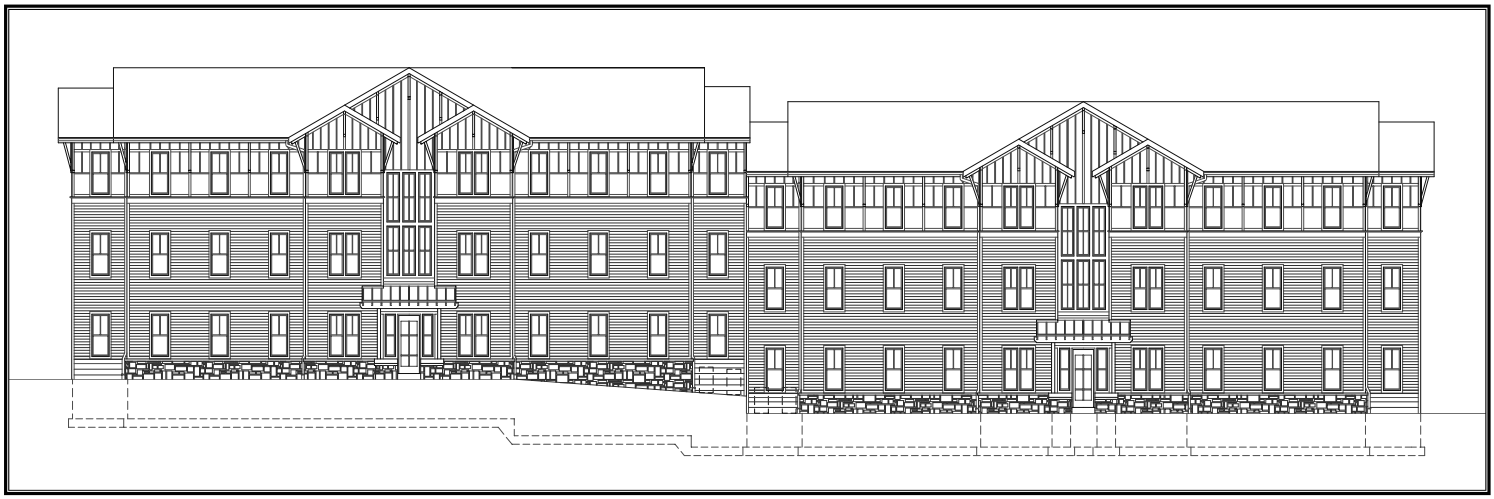
ASHRAE STANDARD 62.1
VENTILATION ANALYSIS



UNIVERSITY RIDGE
AT EAST STROUDSBURG UNIVERSITY
EAST STROUDSBURG, PA

PREPARED FOR:
JAE-WEON JEONG, PH.D.

BY:
MATTHEW CARR
MECHANICAL OPTION
OCTOBER 5, 2006

Table of Contents

Executive Summary 2

Ventilation Rate vs. IAQ Procedure 3

Purpose 4

Assumptions 4

Procedure 5

Analysis 6

Conclusions 7

Appendix A 8

Appendix B 13

References 16

Executive Summary

This report is intended to analyze the ventilation of the University Ridge student housing complex at East Stroudsburg University using the ASHRAE's Standard 62.1 Ventilation for Acceptable Indoor Air Quality. University Ridge is a 10 building complex of 160,000 ft^2 with four person apartments which are naturally ventilated with operable windows according to the required percentage of free area. Along with apartments, the complex also contains a commons area which includes lounges, a game room, conference room, offices and meeting room.

Each of these previously described spaces are conditioned by split system DX duct furnace air handling units which are supplied by hot water from an adjacent water heater and each has an individual condensing unit. Each air handling unit supplies around 2,500 CFM of re-circulated air and a cooling capacity of 2.5 to 3.5 tons.

Due to the spaces being naturally ventilated, the amount of overall complaints due to sick buildings has been shown to be statistically lower.[1] However, naturally ventilated systems must be used with caution due to certain conditions that affect performance, such as climatic, wind or atmospheric conditions.

After analysis of the occupied spaces, it was found that only one unit, DF-1, did not meet Standard 62.1 on mechanical ventilation alone. All spaces which require natural ventilation meet or exceed the standard.

The following report is prepared assuming that the windows are inoperable and require the proper amount of ventilation as stated in Section 6 of Standard 62.1 and that ventilation efficiency is 100%.

Ventilation Rate vs. IAQ Procedure

ASHRAE Standard 62.1 lists two acceptable procedures to properly ventilate an occupied space with the required amount of outdoor air. Both methods serve as a way to effectively remove and reduce air-borne contaminants.

The Indoor Air Quality Procedure (IAQ) focuses on the amount of contaminants in the air and how much they need to be reduced by, given the concentration, to maintain acceptable indoor air quality. This procedure is based on system design parameters that analyze the contaminant sources, concentration levels, and the perceived acceptable concentration levels. Also, the IAQ procedure allows for the use of filters and such air cleaning procedures to be taken account of and used counted as removing contaminants. This procedure is mainly used where a design must attain specific contaminant levels and strengths in such places as hospitals or laboratories.[1]

The Ventilation Rare Procedure (VRP) is a procedure used when minimum outdoor air is to be determined for general spaces. Predetermined outdoor air intake levels are used based on the spaces occupancy category. These predetermined rates are determined from the amount of contaminants and the source strengths for that particular type of space. The prescribed rates are meant to dilute and exhaust the contaminated air at a sufficient rate to maintain an acceptable indoor air quality. This VRP also accounts for the method in which air is delivered to a space using correction factors. When combining spaces into zones, this method determines the amount of outdoor air required in the zones.

By comparison, the Ventilation Rate Procedure is a much more generalized, quicker and less in depth way of finding acceptable indoor air quality levels then the IAQ procedure. The IAQ procedure requires an intimate level of knowledge of the spaces, which is usually hard to come by during design, and thus requires more time for analysis. The VRP does not account for air cleaning devices like the IAQ method and therefore a space might provide more fresh air than might actually be needed. The IAQ procedure is best used for spaces which are sensitive to contaminant levels while the Ventilation Procedure is best used for generalized space where little information is known.

Purpose

The purpose of the standard as stated in ANSI/ASHRAE Standard 62.1 is to "specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects." The standard is used as a basis for determining the amount of outdoor air required to supply an occupied space with enough fresh air to keep contaminants, such as pollution and ozone, to a minimum. This standard also takes into account indoor pollutants and re-circulated air when finding a required amount. Two methods can be applied to obtain the said results, either the Ventilation Rate Procedure or the Indoor Air Quality Procedure. For the purposes of this report, the Ventilation Rate Procedure shall be used.

Assumptions

- Occupants Category for minimum ventilation rate in breathing zones (Table 6-1) shall be assumed in conjunction with architectural plans for occupancy conditions in the breathing zone.
- Occupant Density will be assumed as the same number of beds per apartment unit and the default values for density from Table 6-1 in the standard.
- Exhaust ventilation will be ignored for the purposes of this report. Spaces excluded were bathrooms, janitorial and electrical closets, and storage areas.
- Existing ventilation for spaces such as Vestibules and Stairwells were neglected.
- It is assumed that there is no smoking allowed in any of the spaces.
- Outdoor air is of sufficient quality to be used as ventilation without filtering.
- All operable windows are assumed to be closed and spaces are to be mechanically ventilated.
- All areas are taken from the inside of finished walls.

Procedure

Step 1: Occupied zones are identified and occupancy category, occupancy density and areas are taken from an electronic set of construction drawings.

Step 2: Determine R_a and R_p based on the assumptions above and Table 6-1 in Standard 62.1.

Step 3: Determine the Breathing Zone Outdoor Air Flow using the equation $V_{bz} = R_p P_z + R_a A_z$

Step 4: Determine the Zone Air Distribution Effectiveness (E_z) from Table 6-2 Standard 62.1 and the configuration of the supply of cool air.

Step 5: Calculate the Zone Outdoor Air Flow: $V_{oz} = V_{bz}/E_z$

Step 6: Find the Zone Primary Airflow V_{pz} from the Construction Drawings.

Step 7: Calculate the Primary Outdoor Air Fraction: $Z_p = V_{oz}/V_{pz}$

Step 8: Calculate the Uncorrected Outdoor Air Intake:
$V_{ou} = D \Sigma_{all\ zones} R_p P_z + \Sigma_{all\ zones} R_a A_z$
A conservative diversity factor D of 1 was used because no data is available on the variance in population; therefore the assumption that P_s was equal to P_z was used.

Step 9: Determine the System Ventilation Efficiency E_v, using the value of Z_p as determined earlier, from Table 6-3.

Step 10: Calculate the Outdoor Air Intake: $V_{ot} = V_{ou}/E_v$

Analysis

The calculations in the Appendix analyze the amount of air required by 62.1 assuming that the windows were not operable and required mechanical ventilation. Also, the spaces that were designed with mechanical ventilation were compared to the found values. Compliance with Standard 62.1 Section 5, which deals with natural ventilation, was also verified using occupiable floor areas and operable window free areas.

In Building 1, the First Floor is used as a commons area for the complex. Although this area has operable windows, ventilation is supplied by three separate units to the spaces. It was found after ASHRAE Standard 62.1 analysis that only unit DF-2 did not supply a sufficient amount of ventilation air to the spaces as seen in Appendix A. However, as previously stated, these two spaces are connected by a permanently unobstructed opening of sufficient size to the exterior wall with operable windows and can be argued to have enough outdoor air to meet 62.1. Units DF-3 and DF-4 supply their zones with a more than adequate amount of fresh air thus beating the Standard. The first, second, and third floor meet the requirements for window free area for natural ventilation as stated in Section 5 of 62.1 and can therefore be used for ventilation. If this was not the case, the whole building would need 1,452 CFM of outdoor air to meet the indoor air requirements of Standard 62.1.

Analysis of Building 4 resulted in compliance with Section 5 of the Standard requiring 344 ft^2 of window area and having an actual area of 374 ft^2. The required amount of outside air for mechanical ventilation would be 267 CFM per floor. Investigation of Buildings 2-3,5-10 resulted in almost the same results as Building 4. The operable windows met the Standard with 401 ft^2 of required floor area and having 404 ft^2 of window area. The required amount of outside air for mechanical ventilation would be 270 CFM per floor.

During analysis, the only systems that had a minor difference in their zone primary outdoor air fraction (Z_p) were DF-2 and DF-4; however, they only caused a minor difference since the max Z_p for the systems were 0.228 and 0.196 respectively. These numbers resulted in system

ventilation efficiency (E_v) of 0.9. Since, most of the units were considered single zone, nominal outside air (V_{oz}) and required outside air (V_{ot}) were mostly equal as seen in Appendix A. The only systems that deviated from this were the two systems with different Z_p values.

Conclusions

After evaluation of compliance of the mechanical system with ASHRAE Standard 62.1, it was found that all spaces comply except for zones on unit DF-2. All spaces utilizing natural ventilation from operable windows also pass Section 5 of Standard 62.1. As a result of this natural ventilation, much energy is saved because of the reduced air that must be heated and cooled to maintain a comfortable temperature and have been shown to have less sick building complaints as a result of the decrease in probability of a moisture problem. Overall, the design seems to be accurate and in order.

Appendices

Appendix A

Building 1

Basement Level

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}		
DF-2	TV Room	633	13	0.06	5	103	1.0	103	700	0.147	103	0.9	114		
	Game Room	490	10	0.18	7.15	160	1.0	160		0.228	160	0.9	178		
														Required OA	292
														Actual OA	150
DF-3	Fitness Room	212	5	0.06	20	113	1.0	113		0.141	113	1	113		
	Corridor	188	0	0.06	0	11	1.0	11		0.014	11	1	11		
	Cyber Lounge	653	13	0.06	5	104	1.0	104	800	0.130	104	1	104		
														Required OA	115
														Actual OA	260
DF-4	Conference	175	8	0.06	5	51	1.0	51		0.112	51	1	51		
	Office	105	2	0.06	5	16	1.0	16		0.036	16	1	16		
	Group Meeting Room	633	10	0.06	5	88	1.0	88	450	0.196	88	0.9	98		
	Reception	170	2	0.06	5	20	1.0	20		0.045	20	0.9	22		
	Office	111	2	0.06	5	17	1.0	17		0.037	17	0.9	19		
	Closet	38	0	0.12	0	5	1.0	5		0.010	5	0.9	0.9		
	File Room	107	0	0.12	0	13	1.0	13		0.029	13	0.9	14	Required OA	207
														Actual OA	300
	Total floor area (ft^2)	3515											**Floor Total OA**		**741**

First Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	Unit C - 3 Person Apartment	605	3	0.06	5	51	1.0	51	51	0.073	51	1	51	
	Unit D - 2 Person Apartment	598	2	0.06	5	46	1.0	46	46	0.066	46	1	46	
	(2) - 4 Person Apartment	757	4	0.06	5	65	1.0	65	65	0.093	65	1	65	131
	Corridor/Stairwell	327	0	0.06	0	20	1.0	20	20	0.028	20	1	20	
	Total floor area (ft^2)	2717											**Floor Total OA**	**150**

Second Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	757	4	0.06	5	65	1.0	65	65	0.093	65	1	65	262
	Corridor/Stairwell	306	0	0.06	0	18	1.0	18	18	0.026	18	1	18	
	Total floor area (ft^2)	3028											**Floor Total OA**	**280**

Third Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	757	4	0.06	5	65	1.0	65	65	0.093	65	1	65	262
	Corridor/Stairwell	306	0	0.06	0	18	1.0	18	18	0.026	18	1	18	
	Total floor area (ft^2)	3028											**Floor Total OA**	**280**
													Building 1 Total OA (CFM)	**1452**

First-Third Floor Area (ft^2)	Required Window Free Area	Actual Window Free Area
8773	350.92	365.1

Building 4

First Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	253	0	0.06	0	15	1.0	15	15	0.022	15	1	15	
	Total floor area (ft^2)	2868											**Floor Total OA**	**267**

Second Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	240	0	0.06	0	14	1.0	14	14	0.021	14	1	14	
	Total floor area (ft^2)	2868											**Floor Total OA**	**266**

Third Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	240	0	0.06	0	14	1.0	14	14	0.021	14	1	14	
	Total floor area (ft^2)	2868											**Floor Total OA**	**266**
													Building 4 Total OA (CFM)	800

Floor Area (ft^2)	Required Window Free Area	Actual Window Free Area
8604	344.16	374.4

Buildings 2-3/5-6/7-8/9-10

Basement

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(2) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	185	0	0.06	0	11	1.0	11	11	0.016	11	1	11	
	Total floor area (ft^2)	1434											**Floor Total OA**	**263**

First Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	337	0	0.06	0	20	1.0	20	20	0.029	20	1	20	
	Total floor area (ft^2)	2868											**Floor Total OA**	**272**

Second Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	316	0	0.06	0	19	1.0	19	19	0.027	19	1	19	
	Total floor area (ft^2)	2868											**Floor Total OA**	**271**

Third Floor

	Room Name	Area (ft^2)	Occupancy	R_a (CFM/ft^2)	R_p (CFM/person)	V_{bz} (CFM)	E_z	V_{oz}	V_{pz}	Z_p	V_{ou}	E_v	V_{ot}	Total V_{ot}
DF-1	(4) - 4 Person Apartment	717	4	0.06	5	63	1.0	63	63	0.090	63	1	63	252
	Corridor/Stairwell	316	0	0.06	0	19	1.0	19	19	0.027	19	1	19	
	Total floor area (ft^2)	2868											**Floor Total OA**	**271**

Total Area per Building (ft^2)	Required Window Free Area	Actual Window Free Area
10038	401.52	403.62

Building 2 Total	1096
Building 3 Total	1096
Building 5 Total	1096
Building 6 Total	1096
Building 7 Total	1096
Building 8 Total	1096
Building 9 Total	1096
Building 10 Total	1096
Total OA (CFM)	8768

Appendix B

Building 1

Basement Level

	Room Name	V_{oz}	V_{ot}
DF-2	TV Room	103	114
	Game Room	160	178
DF-3	Fitness Room	113	113
	Corridor	11	11
	Cyber Lounge	104	104
DF-4	Conference	51	51
	Office	16	16
	Group Meeting Room	88	98
	Reception	20	22
	Office	17	19
	Closet	5	0.9
	File Room	13	14

First Floor

	Room Name	V_{oz}	V_{ot}
DF-1	Unit C - 3 Person Apartment	51	51
	Unit D - 2 Person Apartment	46	46
	(2) - 4 Person Apartment	65	65
	Corridor/Stairwell	20	20

Second Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	65	65
	Corridor/Stairwell	18	18

Third Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	65	65
	Corridor/Stairwell	18	18

Building 4

First Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	63	63
	Corridor/Stairwell	15	15

Second Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	63	63
	Corridor/Stairwell	14	14

Third Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	63	63
	Corridor/Stairwell	14	14

Buildings 2-3/5-6/7-8/9-10

Basement

	Room Name	V_{oz}	V_{ot}
DF-1	(2) - 4 Person Apartment	63	63
	Corridor/Stairwell	11	11

First Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	63	63
	Corridor/Stairwell	20	20

Second Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	63	63
	Corridor/Stairwell	19	19

Third Floor

	Room Name	V_{oz}	V_{ot}
DF-1	(4) - 4 Person Apartment	63	63
	Corridor/Stairwell	19	19

References

1. ASHRAE. 2004. *ANSI/ASHRAE Standard 62.1-2004 – Ventilation for Acceptable Indoor Air Quality*. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.