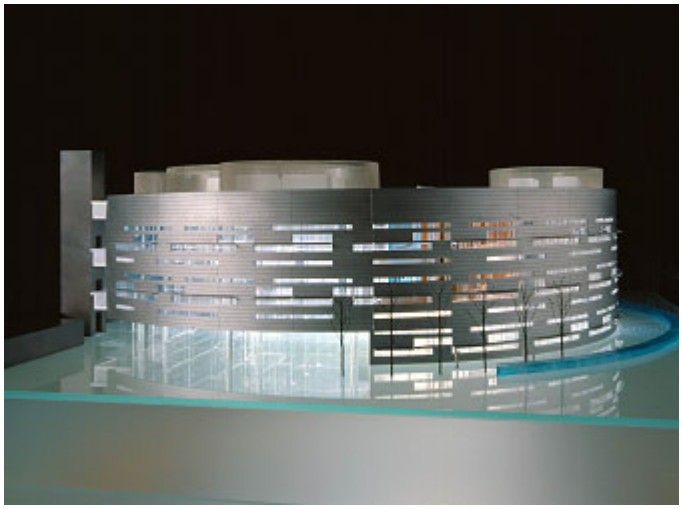
Technical Assignment 1

Building Mechanical & Energy Systems Option

ASHRAE Standard 62.1-2004
Ventilation Compliance Evaluation



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October 4, 2006

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Executive Summary

This report is intended to verify the compliance of the Hauptman-Woodward Medical Research Institute with ASHRAE Standard 62.1-2004, using the prescribed Ventilation Rate Calculation Procedure. The Hauptman Woodward Institute is a 3 story, 73,000 square foot building consisting of office and collaborating space, as well as a biomedical research lab with supporting instrument and experiment spaces. Located between these two distinct areas is a grand atrium and lobby which serves as a gathering space and a bridge between the offices and laboratory spaces.

The Hauptman-Woodward Institute has 3 primary air systems which serve the building. Two rooftop units supply approximately 42,500 cfm of mixed air to the south and west portions of the building, and two air-handling units located in the roof penthouse provide 58,000 cfm of 100% outside air to the laboratory and supporting spaces. A fourth air handling unit, providing 3,000 cfm of makeup air to the penthouse, was not analyzed in this report.

The ventilation distribution effectiveness for each zone was required in order to complete the ventilation rate procedure. According to Table 6-2 of ASHRAE Standard 62.1-2004, the assumed ventilation distribution effectiveness (E_Z) for the Hauptman-Woodward Institute was 0.8, based upon warm air which is supplied and returned through ceiling diffusers.

ASHRAE Standard 62.1-2004 was followed to determine the minimum required amount of outdoor air each system much supply. It was found that for each rooftop unit, the sum of the zone outdoor airflow (ΣV_{OZ}) was less than the design outdoor air intake airflow (V_{OT}). According to the design schedules, the minimum outdoor air was sufficient to comply with Standard 62.1. In addition, the air handling units that supply the laboratory space provide 100% outdoor, thus provide a significantly greater amount of required outside air than is required to the laboratory. It is therefore in compliance with Standard 62.1.

Assumptions

1. The majority of the spaces at the Hauptman-Woodward Medical Research Institute fell into the occupancy categories listed in Table 6-1 of the Standard. For those that did not directly fall into one of those categories, the following assumptions were made:

A. All spaces in the laboratory research area, including Instrument Rooms, Fume Hoods, Equipment Rooms, Chromatography, etc were treated as "Education – Science Laboratories".

B. Vestibules, elevator lobbies, pass throughs, and other areas associated with corridor spaces were treated as corridors.

C. IT Server Rooms were treated as "Educational – Computer Labs".

2. All design occupancies used for the spaces are determined from the supplied architectural drawings by counting the number of chairs in each space. For spaces without furniture, the design condition was determined by the occupant density in Table 6.1 of ASHRAE Standard 62.1-2004.

3. Diversity of 1.0 is assumed as this is the most conservative value for required outdoor air.

4. ASHRAE Standard 62.1-2004 assumes that the outdoor air intake is sufficiently far away from the exhausted air of the building to ensure that outdoor air supply is not recirculated exhausted air.

5. It is assumed that when less then 100% outdoor is supplied that the outdoor air is evenly mixed with the recirculated return air.

6. Appendix A is used to determine System Ventilation Efficiency when the max Z_p exceeds 0.55.

Description of Air Systems

The Hauptman-Woodward Medical Research Institute has 3 air systems in which this report will focus on. This section will describe the systems and what parts of the building they support. In general, the spaces that will be looked at in this report consist of offices, conference areas, library and computer lab spaces, and finally, laboratory and supporting spaces. The 4 Air Handling Units that serve these three systems supply approximately 102,475 CFM to the building, of which 68,600 CFM is outdoor air. For the duration of this report, the three systems which will be described will be referred to as System 1, System 2, and System 3. These systems will each be explained below.

System 1 is a recirculating air system that serves the western offices and supporting spaces on Floors 1-3 of the building. The air-handling unit that coincides with this system is RTU-1, which is located on the roof of the building. In addition to office space, RTU-1 serves conference rooms, server rooms, the institute's library, lunch room and finally, shipping and receiving areas. The unit supplies a total of 14,175 CFM to the building, of which 3,500 CFM is recirculated.

System 2 is also a recirculating air system that serves the south office spaces on floors 1-3 of the building as well as the three story atrium. The air handling unit that coincides with this system is RTU-2, which is located next to RTU-1 on the roof of the building. The unit supplies a total of 28,300 CFM to the building, of which 7,075 CFM is recirculated to the space.

System 3 is a 100% outdoor-air system that serves the laboratory space within the complex. The system is comprised of two air-handlers, herein named AHU-1 and AHU-2. These units are connected via supply and return plenums and together, provide the necessary supply air to handle 100% of the anticipated load. Located in this space are the primary research labs, as well as supporting space including growth labs, equipment and instrument rooms, fume hoods, etc. Each unit supplies 29,000 CFM outdoor air, for a total of 58,000 CFM to the space.

Procedure

The procedure used for determining the outdoor air intake flow (V_{ot}) for each air-handling unit follows the steps outlined in section 6.2 of ASHRAE 62.1- 2004. Below, each step describes the necessary equations and variables to complete the procedure. Refer to the Assumptions section for any necessary assumptions related to this procedure.

Step 1:
For each space, find the values for the zone floor areas ($\mathbf{A_z}$) In addition, determine the zone population ($\mathbf{P_z}$). Each of these values can be determined from the building architectural plans. Zone population was determined by counting the number of chairs for each space. In the instance that no occupancy density is provided, Table 6-1 in the standard provides default values to calculate zone population.

Step 2:
Calculate Breathing Zone Outdoor Airflow ($\mathbf{V_{bz}}$):

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

Where:
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

Values for the outdoor airflow rate required per unit area (R_a) and the outdoor airflow rate required per person ($\mathbf{R_p}$) can be determined from Table 6-1.

Step 3:
Determine the Zone Air Distribution Effectiveness ($\mathbf{E_z}$) from Table 6-2, based on the design of the air distribution of the building.

Step 4:
Determine the Zone Outdoor Airflow ($\mathbf{V_{oz}}$) based on the following:

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

Step 5:
Determine the Zone Primary Outdoor Air Fraction ($\mathbf{Z_p}$) for each zone in the system:

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

Where:
V_{pz} = Zone primary airflow

Step 6:
Determine System Ventilation Efficiency ($\mathbf{E_v}$) by consulting Table 6-3 or Appendix A in the standard. 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 the procedure described in Appendix A should be used. For the Hauptman-Woodward Medical Research Institute, each method will be used since both cases will occur. See Step 7 below for the procedure and equations used from ASHRAE Standard 62.1-2004 – Appendix A. *If the System Ventilation Efficiency (E_v) can be determined from table 6-3, proceed to Step 8.*

Step 7:
ASHRAE Standard 62.1-2004 Appendix A:
The information and equations prescribed in this step 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.

A. Calculate the ratio of the system population to the sum of the zone populations. This is called the Diversity Factor (D).

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

Where:
P_s = System population

Since the System Population is the sum of each zone, the diversity factor is 1.

B. Calculate the Uncorrected Outdoor Air Intake ($\mathbf{V_{ou}}$):

$$V_{ou} = D*\Sigma R_p*P_z + \Sigma R_a*A_z$$

C. Calculate the System Primary Airflow (**V_{ps}**). The sum of the zone primary airflows is the total supply air from the AHU to all the spaces it serves.

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

D. Calculate the Average Outdoor Air Fraction (**X_s**):

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

E. Calculate the Discharge Outdoor Air Fraction (**Z_d**):

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

For VAV systems, the zone discharge airflow (**V_{dz}**) is equal to the amount of supply air to the space.

F. Calculate the System Ventilation Efficiency (**E_v**):

$$E_{vz} = 1 + X_s - Z_d$$
$$E_v = minimum\ (E_{vz})$$

Step 8:
Calculate the Occupant Diversity (**D**). The diversity factor is the ratio of the system populations to the sum of the zone populations.

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

Where:
P_s = System population

Step 9:
Calculate the Uncorrected Outdoor Air Intake (V_{ou}). The uncorrected outdoor air intake is adjusted for diversity.

$$V_{ou} = D^*\Sigma R_p^*P_z + \Sigma R_a^*A_z$$

Step 10:
Determine the Design Outdoor Air Intake Flow (**V_{ot}**):

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

Calculations

Following the procedure outlined in the previous section, the design outdoor air intake flow ($\mathbf{V_{ot}}$) will be calculated in this section. For all equations and variables used in the calculation, refer back to the Procedure section.

It was observed after computing the primary outdoor air fractions ($\mathbf{Z_p}$) that System 1 had a primary outdoor air fraction greater than 0.55. Since this was the case, the system efficiency ($\mathbf{E_v}$) was calculated from Appendix A. For System 2, the zone primary outdoor air fraction was greater than 0.55; therefore the system efficiency was calculated from Table 6-3. Since the procedure using Appendix A requires one extra step of calculations, System 1 will be shown to demonstrate the procedure listed in the previous section.

As shown in the appendices, the critical zone for System 1 was the Computer/Visual lab (Room 221) located on the west side of the building. The lab has an area of 270 square feet and has a supply of 300cfm. To calculate the design outdoor air intake flow ($\mathbf{V_{ot}}$) for System 1, the following steps were used, as outlined in the procedure:

Step 1:
A_z = 270 square feet
P_z = 10 people

Step 2:
R_p = 10 cfm/person
R_a = 0.12 cfm/square foot
A_z = 270 square feet
P_z = 10 people
$V_{bz} = R_p*P_z+R_a*A_z$ = (10 cfm/person)*(6 people) + (0.12 cfm/square foot)*(270 square feet)
V_{bz} = 92.4 cfm

Step 3:
E_z = 0.8 (from Table 6-2, for ceiling supply of warm air 15^{O}F or more above space temperature and ceiling return)

Step 4:
$V_{oz} = V_{bz} / E_z$ = 92.4 cfm / 0.8
V_{oz} = 116 cfm

Step 5:
$Z_p = V_{oz} / V_{pz} = 116$ cfm / 150 cfm
$Z_p = 0.77$
Max. $Z_p = 0.77$

Step 6:
Must follow Appendix A procedure to find $E_{v,\ since}$ $Z_p = 0.77 > 0.55$

Step 7A:
$D = P_s / (\Sigma_{all\ zones} P_z)$
where: $P_s = \Sigma_{all\ zones} P_z$
$D = 1.0$

Step 7B:
$V_{ou} = D*\Sigma R_p*P_z + \Sigma R_a*A_z = (1.0)*\Sigma R_p*P_z + \Sigma R_a*A_z$
$V_{ou} = \Sigma V_{oz}$
$V_{ou} = 2{,}504$ cfm

Step 7C:
$V_{ps} = \Sigma V_{pz}$
$V_{ps} = 7{,}430$ cfm

Step 7D:
$X_s = V_{ou} / V_{ps} = 2{,}504$ cfm / 7,430 cfm
$X_s = 0.34$

Step 7E:
$Z_d = V_{oz} / V_{dz} = 116$ cfm / 300 cfm
$Z_d = 1.26$

Step 7F:
$E_{vz} = 1 + X_s - Z_d = 1 + 0.34 - 0.39$
$E_{vz} = 0.95$

Step 7G:
$E_v =$ minimum (E_{vz})
$E_v =$ minimum $(0.95) = 0.95$

Step 8:

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

$D = 1.0$

Step 9:

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

$V_{ou} = \Sigma V_{oz}$

$V_{ou} = 2{,}504$ cfm

Step 10:

$V_{ot} = V_{ou} / E_v = 2{,}504$ cfm $/ 0.95$

$V_{ot} = 2{,}635$ cfm

Discussion

Comparison of Nominal Outside Air and Required Outside Air for Each System

System 1:

RTU-1 supplies mixed air to floors 1-3 of the west side of the building. Following the procedure of ASHRAE 62.1-2004, the required outside airflow to the space was determined to be 2,504 cfm, and the design outdoor air intake flow was 2,635 cfm. Since the design as verified by the mechanical schedules, the actual amount of outdoor air supplied to the space from the unit is 3,500cfm and the total air supply was 14,175 cfm. Since the actual value of outdoor air supplied to the unit is greater than the required outdoor air quantity, *RTU-1 is in compliance with ASHRAE Standard 62.1-2004*.

System 2:

RTU-2 supplies mixed air to floors 1-3 of the south side of the building, which is predominantly office space and includes the 3-story atrium. Following the procedure of ASHRAE 62.1-2004, the required outside airflow to the space was determined to be 3,530 cfm, and the design outdoor air intake flow was 5,885 cfm. As verified by the mechanical schedules, the actual amount of outdoor air supplied to the space from the unit is 7,075 cfm and the total air supply was 28,300 cfm. Since the actual value of outdoor air supplied to the unit is greater than the required outdoor air quantity, *RTU-2 is in compliance with ASHRAE Standard 62.1-2004*.

System 3:

AHU-1 and AHU-2 are ducted together in parallel, and combined provide 100% outside air to the laboratory space. Following the procedure of ASHRAE 62.1-2004, the required outside airflow for the space was determined to be 5,892 cfm. As verified by the mechanical schedules, the actual amount of outdoor air supplied to the unit is 58,000 cfm. Since the actual value of outdoor air supplied to the unit is greater than the required outdoor air quantity, *the system served by AHU-1 and AHU-2 is in compliance with ASHRAE Standard 62.1-2004*.

Ventilation Rate Procedure compared to Indoor Air Quality Procedure

Within ASHRAE Standard 62.1-2004, two different methods are described for determining required outdoor air requirements. The first method is the Ventilation Rate Procedure, which is a very straightforward means of finding the required outside air rates. Alternatively, the Indoor Air Quality Procedure is an alternate way to determine these requirements. The Indoor Air Quality Procedure is more of a performance-based design approach, in that it analyzes the concentration of contaminants in the space. Below, each method will be discussed and their major differences and applications will be compared.

Ventilation Rate Procedure

The method used in this report to determine the amount of required air at the Hauptman-Woodward Medical Research Institute is the Ventilation Rate Procedure. This procedure has a very straightforward approach in that it consists of a series of equations for find the rate of outside air intake to the building. If all floor areas, occupancies, and uses are known, this process can be followed very easily. The Standard lists in Table 6-1 of Standard 62.1-2004 general contaminant concentrations in various space designations, and provides design values based on floor areas and occupancy levels.

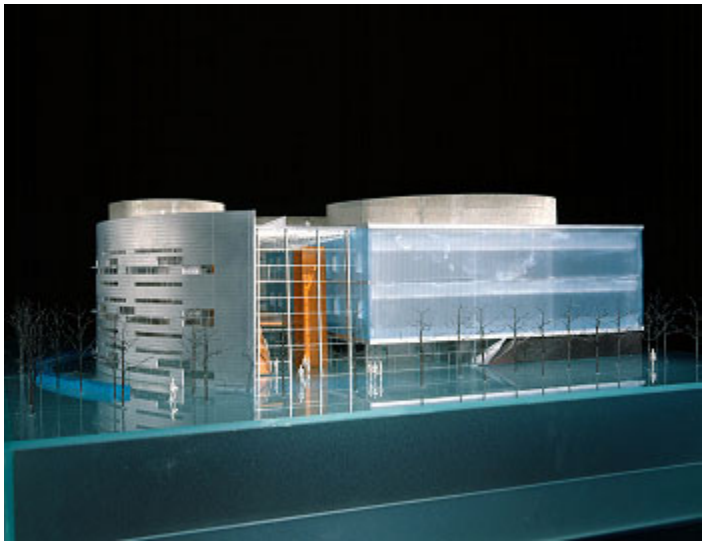
Indoor Air Quality Procedure

The Indoor Air Quality Procedure defines a number of contaminants as well as acceptable levels that are typical in different types of spaces. Using these constraints, the procedure is able to help one analyze the concentration of contaminants in the space and provides a target value for the concentration of each contaminant within each space. This procedure allows for adjustment by other measures to reduce the levels of contaminants in the system, by means of air cleaning devices or other contaminant removal systems. In addition, the selection of building materials that contain fewer impurities can also reduce the amount of contamination to the building.

Comparison

The Ventilation Rate Procedure and Indoor Air Quality Procedure both provide an accurate procedure to verify the amount of outside air required to a particular space; however the Ventilation Rate procedure presents an efficient way to determine the acceptable ventilation rate without the requirement of much information. For most practical purposes, the Indoor Air Quality Procedure is too in-depth and could provide difficulty if building information is not available. In addition the simplicity of the Ventilation rate procedure makes its use effective at any stage of the design process, most importantly in the schematic design phase when building materials may not be specified. The Indoor Air Quality Procedure would most likely be better suited to specialized spaces where the contaminant levels were crucial to the function of the building.

Appendices



Appendix A – Space Characteristics

System 1: RTU-1

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy
102	Seminar Room	Lecture Room	415	27
103	Seminar Room	Lecture Room	415	27
104	Lecture Room	Lecture Room	550	27
114	Shower/Locker	Restroom	120	0
115	Storage	Storage	290	0
116	Storage	Storage	490	0
117	Purchasing	Office	350	1
119	Building Facilities	Office	210	1
120	Receiving/Storage/Loading	Shipping/Receiving	310	0
202/203	Lunch Room/Kitchen	Multi-Purpose	1250	54
219	IT Office	Office Space	120	1
220	IT Office	Office Space	120	1
221	Computer Lab/Visual Room	Computer Lab	270	6
223	Conferemce Room	Conference Room	440	10
224	Server Room	Computer Room	350	0
225	Mens Restroom	Restroom	210	
226	Womens Restroom	Restroom	190	
227	Corridor	Corridor	780	0
229	Elevator Vestibule	Corridor	250	0
230	Telephone	Office Space	60	1
231	Electrical	Mechanical Room	140	0
262	Storage	Storage	60	0
301	Library	Library	1200	8
319	ACA Office	Office Space	120	1
320	ACA Office	Office Space	120	1
321	IT Office	Office Space	120	1
322	IT Office	Office Space	120	1
323	IT Office	Office Space	120	1
324	Conference Room	Conference Room	440	10
325	IT Room	Office Space	350	2
326	Mens Restroom	Restroom	210	
327	Womens Restroom	Restroom	190	
328	Corridor	Corridor	780	0
330	Elevator Vestibule	Corridor	250	0
331	Electrical	Mechanical Room	120	0
332	Telephone	Office Space	80	1

System 2: RTU-2

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy
AT-100	Lobby/Atrium	Atrium	4800	150
AT-200	Atrium	Atrium		
AT-300	Atrium	Atrium		
121	Open Office	Office Space	1115	9
122	Personnel Manager	Office Space	105	1
123	Accounting	Office Space	110	1
124	Accounting	Office Space	110	1
125	Development	Office Space	110	1
126	Development	Office Space	110	1
127	Conference	Conference Room	190	8
128	Development	Office Space	200	1
129	Board Member	Office Space	200	1
130	CFO	Office Space	200	1
131	Vice President	Office Space	200	1
132	President	Office Space	200	1
133	Executive Director	Office Space	200	1
134	Board Room	Conference Room	775	20
135	Mens Restroom	Restroom	230	0
136	Womens Restroom	Restroom	220	0
137	Corridor/Kitchenette	Corridor	460	0
139	Workroom Storage	Storage	300	1
140	Graphics	Office Space	340	2
142	Coat Closet	Storage	15	
143	Reception	Office Space	530	3
204	Open Office	Office Space	2325	12
205	PI Office	Office Space	120	1
206	PI Office	Office Space	120	1
207	PI Office	Office Space	120	1
208	PI Office	Office Space	120	1
209	PI Office	Office Space	120	1
210	PI Office	Office Space	120	1
211	PI Office	Office Space	120	1
212	PI Office	Office Space	120	1
213	PI Office	Office Space	120	1
214	PI Office	Office Space	120	1
215	PI Office	Office Space	120	1
216	PI Office	Office Space	120	1
217	PI Office	Office Space	120	1
218	PI Office	Office Space	120	1

System 2: RTU-2 (cont'd)

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy
302	Open Office	Office Space	2325	24
305	PI Office	Office Space	120	1
306	PI Office	Office Space	120	1
307	PI Office	Office Space	120	1
308	PI Office	Office Space	120	1
309	PI Office	Office Space	120	1
310	PI Office	Office Space	120	1
311	PI Office	Office Space	120	1
312	PI Office	Office Space	120	1
313	PI Office	Office Space	120	1
314	PI Office	Office Space	120	1
315	PI Office	Office Space	120	1
316	PI Office	Office Space	120	1
317	PI Office	Office Space	120	1
318	PI Office	Office Space	120	1

System 3: AHU-1, 2

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy
105	Electron Microscopy	Laboratory	725	6
106	Storage	Storage	175	0
107	Scintillation Counter	Laboratory	210	0
108	Radioisotope Lab (Low Level)	Laboratory	125	1
109	Radioisotope Lab (High Level)	Laboratory	121	1
110	Radioisotope Storage	Storage	42	0
111	Material Storage	Storage	410	0
112	Corridor	Corridor	650	0
113	Bulk Storage	Storage	410	0
228-1	Research Lab	Laboratory	900	2
228-2	Research Lab	Laboratory	900	2
228-3	Research Lab	Laboratory	755	2
228-4	Research Lab	Laboratory	900	2
228-5	Research Lab	Laboratory	795	2
228-6	Research Lab	Laboratory	795	2
228-7	Research Lab	Laboratory	795	2
228-8	Research Lab	Laboratory	375	2
228-9	Research Lab	Laboratory	900	2
228-10	Research Lab	Laboratory	900	2
238	CG Robotics Lab	Laboratory	700	2
239,240	Equipment/Shared Cold Room	Laboratory	600	0
243	Chromatography	Laboratory	240	0
252	Autoclave Room	Laboratory	115	0
253	Insect Room	Laboratory	330	0
254	Bacteria	Laboratory	140	0
255	Dark Room	Laboratory	85	1
256	Chromatography	Laboratory	225	0
257	Yeast	Laboratory	110	0
245	Write-Up	Laboratory	215	0

System 3: AHU-1, 2 (cont'd)

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy
329-1	Research Lab	Laboratory	900	2
329-2	Research Lab	Laboratory	900	2
329-3	Research Lab	Laboratory	755	2
329-4	Research Lab	Laboratory	900	2
329-5	Research Lab	Laboratory	905	2
329-6	Research Lab	Laboratory	1070	2
329-7	Research Lab	Laboratory	1010	2
329-8	Research Lab	Laboratory	375	2
329-9	Research Lab	Laboratory	900	2
329-10	Research Lab	Laboratory	770	2
339	Dishwashing	Laboratory	210	0
340	Autoclave	Laboratory	110	0
341	Insturment	Laboratory	170	0
343	Equipment	Laboratory	345	0
344	Chromatography	Laboratory	225	0
358	X-Ray Crystallography	Laboratory	725	0
360	X-Ray Pump Room	Laboratory	110	0
361	E. coli Lab	Laboratory	110	0

Appendix B – Outside Air Requirements by Space

System 1: RTU-1

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz People	Occupied Max (cfm)	Vpz Occupied Min (cfm)	Terminal Unit	Rp	Ra	RpPz	RaAz	VBZ	Ez	Voz	Zp
102	Seminar Room	Lecture Room	415	27	600	425	TU-113	7.5	0.06	202.5	24.9	227.4	0.8	284	0.67
103	Seminar Room	Lecture Room	415	27	600	425	TU-113	7.5	0.06	202.5	24.9	227.4	0.8	284	0.67
104	Lecture Room	Lecture Room	550	27	800	750	TU-112	7.5	0.06	202.5	33	235.5	0.8	294	0.39
114	Shower/Locker	Restroom	120	0											
115	Storage	Storage	290	0	225	200	TU-104	0	0.12	0	34.8	34.8	0.8	44	0.22
116	Storage	Storage	490	0	400	700	TU-103	0	0.12	0	58.8	58.8	0.8	74	0.11
117	Purchasing	Office	350	1	350	250	TU-102	5	0.06	5	21	26	0.8	33	0.13
119	Building Facilities	Office	210	1	200	175	TU-101	5	0.06	5	12.6	17.6	0.8	22	0.13
120	Receiving/Storage/Loading	Shipping/Receiving	310	0											
202/203	Lunch Room/Kitchen	Multi-Purpose	1250	54	1000	800	TU-201	7.5	0.06	405	75	480	0.8	600	0.75
219	IT Office	Office Space	120	1	200	75	TU-202	5	0.06	5	7.2	12.2	0.8	15	0.20
220	IT Office	Office Space	120	1	200	100	TU-203	5	0.06	5	7.2	12.2	0.8	15	0.15
221	Computer Lab/Visual Room	Computer Lab	270	6	300	150	TU-204,206	10	0.12	60	32.4	92.4	0.8	116	0.77
223	Conferemce Room	Conference Room	440	10	450	215	TU-207	5	0.06	50	26.4	76.4	0.8	96	0.44
224	Server Room	Computer Room	350	0	100	50	TU-208	10	0.12	0	42	42	0.8	53	1.05
225	Mens Restroom	Restroom	210												
226	Womens Restroom	Restroom	190												
227	Corridor	Corridor	780	0	1150	400	TU-208	0	0.06	0	46.8	46.8	0.8	59	0.15
229	Elevator Vestibule	Corridor	250	0	175	150	TU-208	0	0.06	0	15	15	0.8	19	0.13
230	Telephone	Office Space	60	1	75	30	TU-232	5	0.06	5	3.6	8.6	0.8	11	0.36
231	Electrical	Mechanical Room	140	0	200	200	TU-235	0	0.12	0	16.8	16.8	0.8	21	0.11
262	Storage	Storage	60	0	75	35	TU-207	0	0.12	0	7.2	7.2	0.8	9	0.26

System 1: RTU-1 (cont'd)

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz People	Occupied Max (cfm)	Vpz Occupied Min (cfm)	Terminal Unit	Rp	Ra	RpPz	RaAz	VBZ	Ez	Voz	Zp
301	Library	Library	1200	8	700	600	TU-301	5	0.06	40	72	112	0.8	140	0.23
319	ACA Office	Office Space	120	1	150	75	TU-302	5	0.06	5	7.2	12.2	0.8	15	0.20
320	ACA Office	Office Space	120	1	175	75	TU-303	5	0.06	5	7.2	12.2	0.8	15	0.20
321	IT Office	Office Space	120	1	175	125	TU-304	5	0.06	5	7.2	12.2	0.8	15	0.12
322	IT Office	Office Space	120	1	125	75	TU-305	5	0.06	5	7.2	12.2	0.8	15	0.20
323	IT Office	Office Space	120	1	150	75	TU-306	5	0.06	5	7.2	12.2	0.8	15	0.20
324	Conference Room	Conference Room	440	10	450	250	TU-307	5	0.06	50	26.4	76.4	0.8	96	0.38
325	IT Room	Office Space	350	2	450	100	TU-308	5	0.06	10	21	31	0.8	39	0.39
326	Mens Restroom	Restroom	210												
327	Womens Restroom	Restroom	190												
328	Corridor	Corridor	780	0	1150	285	TU-309	0	0.06	0	46.8	46.8	0.8	59	0.21
330	Elevator Vestibule	Corridor	250	0	175	40	TU-309	0	0.06	0	15	15	0.8	19	0.47
331	Electrical	Mechanical Room	120	0	200	200	TU-353	0	0.12	0	14.4	14.4	0.8	18	0.09
332	Telephone	Office Space	80	1	400	400	TU-354	5	0.06	5	4.8	9.8	0.8	12	0.03

System 2: RTU-2

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy	Occupied Max (cfm)	Vpz Occupied Min (cfm)	Terminal Unit	Rp	Ra	RpPz	RaAz	Vbz	Ez	Voz	Zp
AT-100	Lobby/Atrium	Atrium	4800	150	12800	7600	TU-127,131	7.5	0.06	1125	288	1413	0.8	1766	0.23
AT-200	Atrium	Atrium					TU-234,237								
AT-300	Atrium	Atrium					TU-342,347								
121	Open Office	Office Space	1115	9	1950	1425	TU-125,134	5	0.06	45	66.9	111.9	0.8	140	0.10
122	Personnel Manager	Office Space	105	1	125	100	TU-135	5	0.06	5	6.3	11.3	0.8	14	0.14
123	Accounting	Office Space	110	1	250	200	TU-133	5	0.06	5	6.6	11.6	0.8	15	0.07
124	Accounting	Office Space	110	1	200	175	TU-132	5	0.06	5	6.6	11.6	0.8	15	0.08
125	Development	Office Space	110	1	125	100	TU-130	5	0.06	5	6.6	11.6	0.8	15	0.15
126	Development	Office Space	110	1	250	200	TU-129	5	0.06	5	6.6	11.6	0.8	15	0.07
127	Conference	Conference Room	190	8	300	225	TU-126	5	0.06	40	11.4	51.4	0.8	64	0.29
128	Development	Office Space	200	1	225	200	TU-123	5	0.06	5	12	17	0.8	21	0.11
129	Board Member	Office Space	200	1	225	200	TU-121	5	0.06	5	12	17	0.8	21	0.11
130	CFO	Office Space	200	1	225	200	TU-118	5	0.06	5	12	17	0.8	21	0.11
131	Vice President	Office Space	200	1	350	225	TU-117	5	0.06	5	12	17	0.8	21	0.09
132	President	Office Space	200	1	225	200	TU-115	5	0.06	5	12	17	0.8	21	0.11
133	Executive Director	Office Space	200	1	225	200	TU-114	5	0.06	5	12	17	0.8	21	0.11
134	Board Room	Conference Room	775	20	750	600	TU-116	5	0.06	100	46.5	146.5	0.8	183	0.31
135	Mens Restroom	Restroom	230	0											
136	Womens Restroom	Restroom	220	0											
137	Corridor/Kitchenette	Corridor	460	0	375	200	TU-119	0	0.06	0	27.6	27.6	0.8	35	0.17
139	Workroom Storage	Storage	300	1	350	300	TU-122	0	0.12	0	36	36	0.8	45	0.15
140	Graphics	Office Space	340	2	400	300	TU-120	5	0.06	10	20.4	30.4	0.8	38	0.13
142	Coat Closet	Storage	15												
143	Reception	Office Space	530	3	650	475	TU-125	5	0.06	15	31.8	46.8	0.8	59	0.12

System 2: RTU-2 (cont'd)

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy	CFM (max)	Vpz CFM (min)	Terminal Unit	Rp	Ra	RpPz	RaAz	Vbz	Ez	Voz	Zp
204	Open Office	Office Space	2325	12	3250	2500	TU-231,233,236	5	0.06	60	139.5	199.5	0.8	249	0.10
205	PI Office	Office Space	120	1	225	125	TU-251	5	0.06	5	7.2	12.2	0.8	15	0.12
206	PI Office	Office Space	120	1	175	125	TU-250	5	0.06	5	7.2	12.2	0.8	15	0.12
207	PI Office	Office Space	120	1	200	125	TU-249	5	0.06	5	7.2	12.2	0.8	15	0.12
208	PI Office	Office Space	120	1	150	125	TU-248	5	0.06	5	7.2	12.2	0.8	15	0.12
209	PI Office	Office Space	120	1	200	125	TU-247	5	0.06	5	7.2	12.2	0.8	15	0.12
210	PI Office	Office Space	120	1	225	125	TU-246	5	0.06	5	7.2	12.2	0.8	15	0.12
211	PI Office	Office Space	120	1	150	125	TU-245	5	0.06	5	7.2	12.2	0.8	15	0.12
212	PI Office	Office Space	120	1	200	125	TU-244	5	0.06	5	7.2	12.2	0.8	15	0.12
213	PI Office	Office Space	120	1	200	125	TU-243	5	0.06	5	7.2	12.2	0.8	15	0.12
214	PI Office	Office Space	120	1	150	125	TU-242	5	0.06	5	7.2	12.2	0.8	15	0.12
215	PI Office	Office Space	120	1	225	125	TU-241	5	0.06	5	7.2	12.2	0.8	15	0.12
216	PI Office	Office Space	120	1	225	125	TU-240	5	0.06	5	7.2	12.2	0.8	15	0.12
217	PI Office	Office Space	120	1	150	125	TU-239	5	0.06	5	7.2	12.2	0.8	15	0.12
218	PI Office	Office Space	120	1	200	150	TU-238	5	0.06	5	7.2	12.2	0.8	15	0.10
302	Open Office	Office Space	2325	24	3250	2100	TU-334,337,341,346,348	5	0.06	120	139.5	259.5	0.8	324	0.15
305	PI Office	Office Space	120	1	175	75	TU-352	5	0.06	5	7.2	12.2	0.8	15	0.20
306	PI Office	Office Space	120	1	225	75	TU-351	5	0.06	5	7.2	12.2	0.8	15	0.20
307	PI Office	Office Space	120	1	175	75	TU-350	5	0.06	5	7.2	12.2	0.8	15	0.20
308	PI Office	Office Space	120	1	125	75	TU-349	5	0.06	5	7.2	12.2	0.8	15	0.20
309	PI Office	Office Space	120	1	225	75	TU-345	5	0.06	5	7.2	12.2	0.8	15	0.20
310	PI Office	Office Space	120	1	150	75	TU-344	5	0.06	5	7.2	12.2	0.8	15	0.20
311	PI Office	Office Space	120	1	225	75	TU-343	5	0.06	5	7.2	12.2	0.8	15	0.20
312	PI Office	Office Space	120	1	150	75	TU-340	5	0.06	5	7.2	12.2	0.8	15	0.20
313	PI Office	Office Space	120	1	125	75	TU-339	5	0.06	5	7.2	12.2	0.8	15	0.20
314	PI Office	Office Space	120	1	150	75	TU-338	5	0.06	5	7.2	12.2	0.8	15	0.20
315	PI Office	Office Space	120	1	150	75	TU-336	5	0.06	5	7.2	12.2	0.8	15	0.20
316	PI Office	Office Space	120	1	200	100	TU-335	5	0.06	5	7.2	12.2	0.8	15	0.15
317	PI Office	Office Space	120	1	150	75	TU-333	5	0.06	5	7.2	12.2	0.8	15	0.20
318	PI Office	Office Space	120	1	125	75	TU-332	5	0.06	5	7.2	12.2	0.8	15	0.20

System 3: AHU-1, 2

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy	Occupied Max (cfm)	Vpz Occupied Min (cfm)	Terminal Unit	Rp	Ra	RpPz	RaAz	Vbz	Ez	Voz
105	Electron Microscopy	Laboratory	725	6	1300	600	TU-109	10	0.18	60	130.5	190.5	0.8	238
106	Storage	Storage	175	0	200	60	TU-111	0	0.12	0	21	21	0.8	26
107	Scintillation Counter	Laboratory	210	0	325	95	TU-111	10	0.18	0	37.8	37.8	0.8	47
108	Radioisotope Lab (Low Level)	Laboratory	125	1	250	75	TU-111	10	0.18	10	22.5	32.5	0.8	41
109	Radioisotope Lab (High Level)	Laboratory	121	1	250	75	TU-110	10	0.18	10	21.78	31.78	0.8	40
110	Radioisotope Storage	Storage	42	0	100	30	TU-110	0	0.12	0	5.04	5.04	0.8	6
111	Material Storage	Storage	410	0	650	310	TU-108	0	0.12	0	49.2	49.2	0.8	62
112	Corridor	Corridor	650	0	500	200	TU-136	0	0.06	0	39	39	0.8	49
113	Bulk Storage	Storage	410	0	650	310	TU-108	0	0.12	0	49.2	49.2	0.8	62
228-1	Research Lab	Laboratory	900	2	2400	700	TU-210	10	0.18	20	162	182	0.8	228
228-2	Research Lab	Laboratory	900	2	2200	800	TU-211	10	0.18	20	162	182	0.8	228
228-3	Research Lab	Laboratory	755	2	1900	1250	TU-212	10	0.18	20	135.9	155.9	0.8	195
228-4	Research Lab	Laboratory	900	2	2200	811	TU-213	10	0.18	20	162	182	0.8	228
228-5	Research Lab	Laboratory	795	2	2300	800	TU-214	10	0.18	20	143.1	163.1	0.8	204
228-6	Research Lab	Laboratory	795	2	2900	1400	TU-225	10	0.18	20	143.1	163.1	0.8	204
228-7	Research Lab	Laboratory	795	2	1700	700	TU-226	10	0.18	20	143.1	163.1	0.8	204
228-8	Research Lab	Laboratory	375	2	800	400	TU-227	10	0.18	20	67.5	87.5	0.8	109
228-9	Research Lab	Laboratory	900	2	1700	725	TU-229	10	0.18	20	162	182	0.8	228
228-10	Research Lab	Laboratory	900	2	1600	725	TU-230	10	0.18	20	162	182	0.8	228
238	CG Robotics Lab	Laboratory	700	2	1300	250	TU-215	10	0.18	20	126	146	0.8	183
239,240	Equipment/Shared Cold Room	Laboratory	600	0	1100	350	TU-216	10	0.18	0	108	108	0.8	135
243	Chromatography	Laboratory	240	0	500	125	TU-217	10	0.18	0	43.2	43.2	0.8	54
252	Autoclave Room	Laboratory	115	0	900	100	TU-219	10	0.18	0	20.7	20.7	0.8	26
253	Insect Room	Laboratory	330	0	1000	450	TU-221	10	0.18	0	59.4	59.4	0.8	74
254	Bacteria	Laboratory	140	0	200	100	TU-223	10	0.18	0	25.2	25.2	0.8	32
255	Dark Room	Laboratory	85	1	200	50	TU-222	10	0.18	10	15.3	25.3	0.8	32
256	Chromatography	Laboratory	225	0	650	100	TU-220	10	0.18	0	40.5	40.5	0.8	51
257	Yeast	Laboratory	110	0	200	50	TU-222	10	0.18	0	19.8	19.8	0.8	25
245	Write-Up	Laboratory	215	0	375	100	TU-224	10	0.18	0	38.7	38.7	0.8	48

System 3: AHU-1, 2 (cont'd)

Room Number	Room Name	Space Discription	Az Area (sq.ft)	Pz Occupancy	Occupied Max (cfm)	Vpz Occupied Min (cfm)	Terminal Unit	Rp	Ra	RpPz	RaAz	Vbz	Ez	Voz
329-1	Research Lab	Laboratory	900	2	2300	750	TU-311	10	0.18	20	162	182	0.8	228
329-2	Research Lab	Laboratory	900	2	2200	800	TU-312	10	0.18	20	162	182	0.8	228
329-3	Research Lab	Laboratory	755	2	1900	800	TU-313	10	0.18	20	135.9	155.9	0.8	195
329-4	Research Lab	Laboratory	900	2	2300	825	TU-314	10	0.18	20	162	182	0.8	228
329-5	Research Lab	Laboratory	905	2	2300	800	TU-315	10	0.18	20	162.9	182.9	0.8	229
329-6	Research Lab	Laboratory	1070	2	1700	750	TU-326	10	0.18	20	192.6	212.6	0.8	266
329-7	Research Lab	Laboratory	1010	2	1800	850	TU-327	10	0.18	20	181.8	201.8	0.8	252
329-8	Research Lab	Laboratory	375	2	800	625	TU-328	10	0.18	20	67.5	87.5	0.8	109
329-9	Research Lab	Laboratory	900	2	1900	700	TU-330	10	0.18	20	162	182	0.8	228
329-10	Research Lab	Laboratory	770	2	1800	700	TU-331	10	0.18	20	138.6	158.6	0.8	198
339	Dishwashing	Laboratory	210	0	400	100	TU-316	10	0.18	0	37.8	37.8	0.8	47
340	Autoclave	Laboratory	110	0	900	100	TU-317	10	0.18	0	19.8	19.8	0.8	25
341	Insturment	Laboratory	170	0	500	175	TU-318	10	0.18	0	30.6	30.6	0.8	38
343	Equipment	Laboratory	345	0	1000	250	TU-319	10	0.18	0	62.1	62.1	0.8	78
344	Chromatography	Laboratory	225	0	700	275	TU-320	10	0.18	0	40.5	40.5	0.8	51
358	X-Ray Crystallography	Laboratory	725	0	1275	425	TU-322,323,324	10	0.18	0	130.5	130.5	0.8	163
360	X-Ray Pump Room	Laboratory	110	0	200	75	TU-325	10	0.18	0	19.8	19.8	0.8	25
361	E. coli Lab	Laboratory	110	0	400	150	TU-325	10	0.18	0	19.8	19.8	0.8	25

Appendix C – Outdoor Air Comparisons for Main AHUs:

System	Max Zp	Ev	Vou (cfm)	ΣVoz (cfm)	Vot	Min OA (cfm)	Total SA (cfm)	Complies to Standard 62.1-2004
RTU-1	0.77	0.95	2,003	2,504	2,635	3,500	14,175	Yes
RTU-2	0.31	0.6	2,823	3,530	5,885	7,075	28,300	Yes
AHU-1,2	n/a	n/a	4,713	5,892	5,892	29,000	29,000	Yes

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