

# ASHRAE STANDARD 62 VENTILATION REPORT



## THE PENNSYLVANIA STATE UNIVERSITY CHEMISTRY BUILDING UNIVERSITY PARK, PENNSYLVANIA

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MECHANICAL OPTION  
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**CHEMISTRY BUILDING**  
TECHNICAL ASSIGNMENT #1



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## EXECUTIVE SUMMARY

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The Pennsylvania State University Chemistry Building was evaluated using ASHRAE Standard 62 Addendum 'n' to determine if the design ventilation rates meet the suggested rates by the standard. The Chemistry Building is 5 stories with a basement and a mechanical penthouse. The building contains offices, laboratories, conferences, seminars and classrooms as far as educational spaces. Public spaces include lounges, atriums and entryways. Proper ventilation is required in order to have a healthy learning environment.

The laboratories are ventilated using three of the four air handlers. They are ventilated using a constant air volume system. The laboratory air handler's supply CFM ranges from 72,500-100,000 CFM. Supply air consists of 100% outdoor air.

The offices and conference areas are ventilated using the fourth air handler. The spaces served by this air handler are ventilated using a variable air volume system. The supplied from the air handler is comprised of 100% outdoor air, and supplied to the spaces at 72,000 CFM.

It is assumed that there is perfect mixing, and the effectiveness of the units is 100%. All four air handling units meet complied with the standard.

In addition, differences and applications of the Ventilation Rate Procedure and Indoor Air Quality Procedure are discussed.



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## ASSUMPTIONS

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- Outdoor air is acceptable for ventilation.
- The mixing of room and supply air in spaces is perfect.
- Smoking is not permitted inside building.
- Neglect ventilation for mechanical rooms, and shafts.
- Neglect ventilation for electrical rooms, and shafts.
- Neglect ventilation for telecommunication rooms, and shafts.
- Neglect ventilation for lavatory spaces. Transfer air will account for ventilation due to exhaust fans located in these areas.
- Neglect ventilation for janitor closets. Transfer air will account for ventilation due to exhaust fans located in these areas.
- Neglect ventilation for stairways. Transfer air will account for ventilation due to exhaust fans located in these areas.
- Neglect ventilation for Cold Rooms.
- Neglect ventilation for High Resolution Laboratory. This area is on its own ventilation and climate control system.
- Assume that equipment, utility, and instrument spaces are part of the laboratory therefore they shall be ventilated as such.
- In spaces without furniture layouts, where it is not possible to count the number of seats for an occupancy number, occupancy will be determined by Table 6.1 Default Values.



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**ORIGINAL DESIGN CRITERIA**

ZONE	SPACE	OCCUPANTS	SQ FT	OA REQ'T		AHU	CFM	
				CFM/PERS	CFM/FT <sup>2</sup>			
<b>BASEMENT</b>								
1	SMALL INSTRUMENT LAB	023B	8	256	10	0.18	2	575
2	GRR	025	13	256	5	0.06	2	500
3	MEDIUM INSTRUMENT LAB	023A	29	952	10	0.18	2	1550
4	INSTRUMENT RM	023	5	177	10	0.18	2	600
5	OFFICE	026	2	154	5	0.06	2	150
6	OFFICE	024	2	154	5	0.06	2	150
7	OFFICE	022	2	120	5	0.06	2	125
8	OFFICE	021	2	120	5	0.06	2	125
9	OFFICE	020	2	120	5	0.06	2	125
10	OFFICE	023C	2	116	5	0.06	2	125
11	OFFICE	023E	1	102	5	0.06	2	125
12	OFFICE	023F	1	102	5	0.06	2	125
13	MEN'S LAVATORY	R020	N/A	362	N/A	N/A	2	400
14	WOMEN'S LAVATORY	R019	N/A	362	N/A	N/A	2	400
15	LARGE INSTRUMENT LAB	018C	26	867	10	0.18	2	1800
17	SYNTHETIC CHEM	019	4	444	10	0.18	3	1000
18	SMALL INSTRUMENT LAB	018B	6	214	10	0.18	2	525
19	LARGE INSTRUMENT LAB	018A	24	784	10	0.18	2	1350
20	JUMBO INSTRUMENT LAB	017	39	1314	10	0.18	2	2600
21	GRR	001	10	200	5	0.06	3	300
22	FACULTY NMR	003	18	608	10	0.18	3	1000
23	OFFICE	002	2	140	5	0.06	3	125
24	OFFICE	004	1	140	5	0.06	3	125
25	OFFICE	005	1	140	5	0.06	3	125
26	NMR SOLIDS	007	21	706	10	0.18	3	500
27	GENERAL NMR	006	16	544	10	0.18	3	3300
28	GENERAL NMR	009	35	1178	10	0.18	3	6000
29	DIRECTOR'S OFFICE	008	2	144	5	0.06	3	150
30	NMR COMPUTER	010	4	144	10	0.12	3	400
31	UTILITY ROOM	011	2	325	10	0.18	3	900
32	PREP ROOM	012	4	142	10	0.18	3	575
33	TECHNICIANS OFFICE	014	2	142	5	0.06	3	150
34	ENTRYWAY	018	1	224	5	0.06	2	400
35	ELEC. SHOP	016	3	164	10	0.18	3	250
36	HIGH RESOLUTION SUITE	013	N/A	2165	10	0.18	N/A	N/A
37	CONTROL ROOM	015	4	264	5	0.06	N/A	N/A
38	STAIR LOBBY	F001	7	707	7.5	0.06	3	250
39	CORRIDOR	0001	N/A	411	N/A	0.06	2	250
40	WEST STAIR	Z003	N/A	N/A	N/A	N/A	N/A	N/A
41	MAIN STAIR	Z001	N/A	N/A	N/A	N/A	N/A	N/A
42	SOUTH STAIR	Z002	N/A	N/A	N/A	N/A	N/A	N/A



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1ST FLOOR									
43	WEST ENTRYWAY	Q103	3	308	5	0.06	4	750	
44	CHEMICAL STORAGE	130	N/A	N/A	N/A	N/A	4	N/A	
45	CHEMICAL STORAGE	131	N/A	N/A	N/A	N/A	4	N/A	
46	TANK STORAGE	132	N/A	N/A	N/A	N/A	4	N/A	
47	LN2 DISPENSING	133	N/A	N/A	N/A	N/A	N/A	N/A	
48	LOADING DOCK	134	N/A	974	N/A	0.12	N/A	N/A	
49	RECEIVING AND STOCKROOM	125	N/A	1054	N/A	0.12	1	1200	
50	OFFICE	128	1	150	5	0.06	4	325	
51	OFFICE	127	1	150	5	0.06	4	325	
52	OFFICE	126	1	150	5	0.06	4	325	
53	OFFICE	124	1	150	5	0.06	4	325	
54	OFFICE	123	1	150	5	0.06	4	325	
55	SERVER ROOM	122A	1	126	5	0.06	4	500	
56	MECHANICAL SHOP ROOM	121B	10	506	10	0.12	1	1300	
57	SUPERVISOR'S OFFICE	121A	1	160	5	0.06	1	400	
58	OFFICE	121C	1	86	5	0.06	1	275	
59	OFFICE	121D	1	86	5	0.06	1	275	
60	OFFICE	121E	1	86	5	0.06	1	275	
61	ELECTRONIC SHOP	121	19	938	10	0.12	1	1400	
62	RIF OFFICE SUITE	122	10	282	5	0.06	4	650	
63	SYNTHETIC LAB	117A	4	650	10	0.18	1	3825	
64	SYNTHETIC LAB	115A	4	650	10	0.18	2	5050	
65	SYNTHETIC LAB	113A	4	650	10	0.18	2	5450	
66	SYNTHETIC LAB	111A	6	977	10	0.18	2	6300	
67	EQUIP ROOM	119	5	186	10	0.18	1	600	
68	INSTRUMENT ROOM	117	5	186	10	0.18	1	600	
69	EQUIP ROOM	115	5	186	10	0.18	2	600	
70	INSTRUMENT ROOM	113B	5	186	10	0.18	2	600	
71	COMPUTER ROOM	113	3	120	10	0.12	2	450	
72	EQUIP ROOM	111	4	178	10	0.18	2	600	
73	OFFICE	120	1	150	5	0.06	4	325	
74	GRR	118	12	248	5	0.06	4	650	
75	OFFICE	116	1	150	5	0.06	4	400	
76	GRR	114	12	248	5	0.06	4	650	
77	COMPUTER ROOM	112	4	142	10	0.12	4	325	
78	MAIN ELEVATOR LOBBY	F102	22	2152	7.5	0.06	4	100	
79	SYNTHETIC LAB	110A	6	977	10	0.18	2	6750	
80	SYNTHETIC LAB	109A	6	977	10	0.18	3	7200	
81	WOMEN'S LAVATORY	R111	N/A	180	N/A	N/A	2	150	
82	MEN'S LAVATORY	R110	N/A	180	N/A	N/A	2	150	
83	EQUIP ROOM	110	4	170	10	0.18	2	600	
87	EQUIP ROOM	109	5	190	10	0.18	3	600	
88	OFFICE	101D	1	168	5	0.06	4	250	
89	OFFICE	101E	1	104	5	0.06	4	150	
90	COPIER	101F	1	84	5	0.06	4	125	
91	ACADEMIC AFFAIRS	101C	1	102	5	0.06	4	225	
92	OFFICE	101B	1	150	5	0.06	4	425	
93	ACADEMIC AFFAIRS	101A	1	144	5	0.06	4	225	
94	ADADEMIC OFFICE	101	2	476	5	0.06	4	400	



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95	MAIN ENTRY VESTIBULE	Q101	6	642	7.5	0.06	4	1600
96	SEMINAR	102	80	1138	7.5	0.06	3	1200
97	KITCHEN	104C	8	159	7.5	0.18	4	400
98	CONFERENCE	103	15	303	5	0.06	4	450
99	FACULTY SERVICES	104	5	642	5	0.06	4	600
100	MAILROOM	104A	1	79	5	0.06	4	100
101	GRADUATE RECRUITING	105	14	456	5	0.06	4	475
102	GRAD OFFICE	105A	1	128	5	0.06	4	150
103	OFFICE	106	1	128	5	0.06	4	125
104	OFFICE	107	1	128	5	0.06	4	125
105	OFFICE	108	1	152	5	0.06	4	125
107	CORRIDOR	Q102	N/A		N/A	0.06	4	1100
108	CORRIDOR	Q103	N/A	928	N/A	0.06	4	1025
109	WEST STAIR	Z103	N/A	N/A	N/A	N/A	N/A	N/A
110	MAIN STAIR	Z101	N/A	N/A	N/A	N/A	N/A	N/A
111	SOUTH STAIR	Z102	N/A	N/A	N/A	N/A	N/A	N/A

2ND FLOOR								
112	LOUNGE	243	37	370	7.5	0.18	4	1100
113	OFFICE	242	1	150	5	0.06	4	400
114	EQUIP	241	5	190	10	0.18	1	600
115	BIO CHEM LAB	241A	6	994	10	0.18	1	2250
116	COMP	241B	5	190	10	0.12	1	450
117	BIO CHEM LAB	239A	4	665	10	0.18	1	600
118	EQUIP	239	5	190	10	0.18	1	600
119	COLD ROOM	239B	N/A	80	N/A	N/A	1	N/A
120	DARK ROOM	237	N/A	106	N/A	0.5	1	300
121	OFFICE	240	1	150	5	0.06	4	400
122	OFFICE	238	1	150	5	0.06	4	400
123	BIO CHEM LAB	235A	4	665	10	0.18	1	1500
124	EQUIP	235	5	190	10	0.18	1	600
126	GRR	234	12	242	5	0.06	4	800
127	GRR	232	12	242	5	0.06	4	800
128	BIO CHEM LAB	233A		665	10	0.18	1	1500
129	COMP	233	5	190	10	0.12	1	450
131	OFFICE	230	1	150	5	0.06	4	400
132	SYNTHETIC CHEM	229A	4	665	10	0.18	1	3825
133	EQUIP	229	5	190	10	0.18	1	600
134	COMP	227	5	190	10	0.12	1	450
135	OFFICE	228	1	150	5	0.06	4	400
136	GRR	226	12	242	5	0.06	4	800
138	EQUIP	225	5	190	10	0.18	2	600
139	SYNTHETIC CHEM	225A	4	665	10	0.18	2	4200
140	OFFICE	224	1	150	5	0.06	4	400
141	SYNTHETIC CHEM	219B	4	665	10	0.18	2	4475
142	TISSUE CULTURE	223	3	136	10	0.18	2	450
143	LASER ROOM	221	3	136	10	0.18	2	400
144	GRR	222	12	242	5	0.06	4	800
145	BIO CHEM LAB	219A	4	994	10	0.18	2	2250
146	EQUIP	219	5	190	10	0.18	2	600



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147	OFFICE	220	1	150	5	0.06	4	400
148	ELEVATOR LOBBY	F202	5	468	5	0.06	N/A	100
149	BIO CHEM LAB	218A	6	994	10	0.18	2	2250
150	EQUIP	218	4	168	10	0.12	2	600
151	WOMEN'S LAVATORY	R218	N/A	180	N/A	N/A	2	150
152	MEN'S LAVATORY	R217	N/A	180	N/A	N/A	2	150
154	INSTRUMENT LAB	217A	25	994	10	0.18	3	2250
157	EQUIP	217	5	212	10	0.18	3	600
158	STAIR LOBBY	F201	4	402	5	0.06	4	400
159	OFFICE	201E	1	192	5	0.06	4	350
160	OFFICE	201D	1	126	5	0.06	4	350
162	OFFICE	201B	1	130	5	0.06	4	275
163	THEORST SUITE	201	N/A	202	N/A	0.06	4	200
164	OFFICE	201A	1	228	5	0.06	4	250
165	COMPUTER	201F	3	102	10	0.12	4	300
166	CONFERENCE	201G	11	220	5	0.06	4	250
167	LARGE INSTRUMENT LAB	204	22	872	10	0.18	3	1500
168	SMALL INSTRUMENT LAB	204A	5	208	10	0.18	3	800
169	JUMBO INSTRUMENT LAB	207	30	1180	10	0.18	3	1500
170	UTILITY TANK	204	N/A	72	N/A	0.12	3	100
171	OFFICE	202	1	168	5	0.06	4	225
172	OFFICE	203	1	138	5	0.06	4	225
173	OFFICE	205	1	138	5	0.06	4	225
174	OFFICE	206	1	138	5	0.06	4	225
175	OFFICE	208	1	138	5	0.06	4	225
176	GRR	209	11	228	5	0.06	4	450
177	OFFICE	210	N/A	138	N/A	0.12	4	225
178	SMALL INSTRUMENT LAB	207A	5	208	10	0.18	3	800
179	UTILITY TANK	207B	N/A	72	N/A	0.12	3	100
180	LARGE INSTRUMENT LAB	212	22	874	10	0.18	3	1500
181	OFFICE	211	1	138	5	0.06	4	225
182	OFFICE	213	1	138	5	0.06	4	225
183	OFFICE	214	1	138	5	0.06	4	225
184	OFFICE	215	1	138	5	0.06	4	225
185	LOUNGE	216	32	318	7.5	0.18	4	675
186	CORRIDOR	Q203	N/A	948	N/A	0.06	4	1425
187	CORRIDOR	Q201	N/A	146	N/A	0.06	4	800
188	CORRIDOR	Q202	N/A	736	N/A	0.06	4	600
189	MAIN STAIR	Z201	N/A	N/A	N/A	N/A	N/A	N/A
190	WEST STAIR	Z203	N/A	N/A	N/A	N/A	N/A	N/A
191	SOUTH STAIR	Z202	N/A	N/A	N/A	N/A	N/A	N/A

3RD FLOOR								
192	BIO CHEM	335A	6	994	10	0.18	1	2250
193	BIO CHEM	331A	4	665	10	0.18	1	1500
194	BIO CHEM	331B	4	665	10	0.18	1	1500
195	EQUIP	335	5	190	10	0.18	1	600
196	COMP	335B	5	190	10	0.12	1	450
197	INST	331C	2	78	10	0.18	1	600
198	COMP	335C	3	107	10	0.12	1	600





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199	COLD ROOM	331D	N/A	107	N/A	N/A	N/A	N/A
200	LOUNGE	337	37	370	7.5	0.18	4	1100
201	OFFICE	336	1	150	5	0.06	4	400
202	OFFICE	334	1	150	5	0.06	4	400
203	OFFICE	333	1	150	5	0.06	4	400
204	OFFICE	332	1	150	5	0.06	4	400
205	OFFICE	330	1	150	5	0.06	4	400
206	EQUIP	331	7	264	10	0.18	1	900
207	BIO CHEM	327C	4	665	10	0.18	1	1500
208	BIO CHEM	327A	4	665	10	0.18	1	1500
210	COLD ROOM	327D	N/A	78	N/A	N/A	N/A	N/A
211	AUTOCLAVE	329	N/A	107	N/A	N/A	N/A	400
212	TISSUE CULTURE	327B	3	134	10	0.18	1	450
213	GRR	328	12	242	5	0.06	4	800
215	EQUIP	327	6	240	10	0.18	1	750
216	OFFICE	326	1	150	5	0.06	4	400
217	COMP	326A	4	150	10	0.12	4	600
218	COMP	325	5	190	10	0.12	1	450
219	GRR	324	12	242	5	0.06	4	800
221	BIO CHEM	323A	4	665	10	0.12	2	1500
222	BIO CHEM	318B	4	665	10	0.12	2	1500
223	EQUIP	323	5	190	10	0.18	2	600
224	OFFICE	322	1	150	5	0.06	4	400
225	ANATOMY LAB	318D	1	48	10	0.18	2	150
226	RADIO ISOTOPE LAB	318C	5	190	10	0.18	2	600
227	GRR	321	12	242	5	0.06	4	800
228	TISSUE CULTURE	320	3	130	10	0.18	2	450
229	OFFICE	319	1	150	5	0.06	4	400
231	BIO CHEM	318A	4	665	10	0.18	2	1500
232	MASS SPEC PREP LAB	317C	17	665	10	0.18	2	1500
233	MASS SPEC LAB AND SUPPORT	317A	38	1518	10	0.18	3	2975
234	ELEVATOR LOBBY	F302	5	506	5	0.06	N/A	100
235	WOMEN'S LAVATORY	R318	N/A	180	N/A	N/A	3	150
236	MEN'S LAVATORY	R317	N/A	180	N/A	N/A	3	150
241	EQUIP	317	5	190	10	0.18	3	600
242	OFFICE	317B	1	108	5	0.06	3	300
243	SEMINAR	301A	42	844	7.5	0.06	4	1500
244	CONFERENCE	301	18	366	5	0.06	4	300
245	PANTRY	301B	N/A	60	N/A	N/A	4	N/A
246	TOILET	R302	N/A	60	N/A	N/A	4	N/A
247	TOILET	R301	N/A	60	N/A	N/A	4	N/A
248	DEPT SEC	302	1	168	5	0.06	4	275
249	DEPT COPIER	303	1	138	5	0.06	4	225
250	OFFICE	305	1	138	5	0.06	4	225
251	JUMBO INSTRUMENT LAB	304	27	1074	10	0.18	3	1900
252	OFFICE	306	1	138	5	0.06	4	225
253	OFFICE	308	1	138	5	0.06	4	225
254	JUMBO INSTRUMENT LAB	307	30	1180	10	0.18	3	1900
255	UTILITY TANK	307C	N/A	80	N/A	N/A	3	N/A
256	UTILITY TANK	307B	N/A	46	N/A	N/A	3	N/A



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257	GRR	309	11	226	10	0.18	4	450
258	OFFICE	310	1	138	5	0.06	4	225
259	OFFICE	311	1	138	5	0.06	4	225
260	SMALL INSTRUMENT LAB	307A	5	208	10	0.18	3	5000
261	LARGE INSTRUMENT LAB	312	22	872	10	0.18	3	1500
262	OFFICE	313	1	138	5	0.06	4	225
263	OFFICE	314	1	138	5	0.06	4	225
264	OFFICE	315	1	138	5	0.06	4	225
265	LOUNGE	316	32	318	7.5	0.18	4	675
266	CORR	Q303	N/A	968	N/A	0.06	4	925
267	CORR	Q301	N/A	750	N/A	0.06	4	1600
268	CORR	Q302	N/A	732	N/A	0.06	4	600
269	STAIR LOBBY	F301	4	406	5	0.06	4	400
270	WEST STAIR	Z303	N/A	N/A	N/A	N/A	N/A	N/A
271	SOUTH STAIR	Z302	N/A	N/A	N/A	N/A	N/A	N/A

4TH FLOOR								
271	LOUNGE	441	37	374	7.5	0.18	4	1100
272	OFFICE	440	1	150	5	0.06	4	400
273	EQUIP	439	5	190	10	0.18	1	600
274	OFFICE	438	1	150	5	0.06	4	400
275	OFFICE	436	1	150	5	0.06	4	400
276	COMP	437	2	90	10	0.12	1	225
277	INST	435D	5	190	10	0.18	1	600
278	EQUIP	435	5	190	10	0.18	1	600
279	OFFICE	434	1	150	5	0.06	4	400
280	COMP	439B	2	90	10	0.12	1	225
281	SYNTHETIC CHEM	439A	6	994	10	0.18	1	6800
282	SYNTHETIC CHEM	435C	4	665	10	0.18	1	4950
283	SYNTHETIC CHEM	435B	4	665	10	0.18	1	5550
284	SYNTHETIC CHEM	429B	4	665	10	0.18	1	1500
285	INST	434A	3	132	10	0.18	1	400
286	OFFICE	433	1	150	5	0.06	4	400
288	GRR	432	12	235	5	0.06	4	800
289	OFFICE	431	1	150	5	0.06	4	400
290	OFFICE	430	1	150	5	0.06	4	400
291	EQUIP	429	7	272	10	0.18	1	300
292	TISSUE CULTURE	429D	3	106	10	0.18	1	350
293	RADIO ISOTOPE LAB	429C	5	190	10	0.18	1	800
294	SYNTHETIC CHEM	429A	4	665	10	0.18	1	4375
295	SYNTHETIC CHEM	425A	4	665	10	0.18	2	4075
296	SYNTHETIC CHEM	423A	4	665	10	0.18	2	3825
297	COMP	427	5	190	10	0.12	1	300
299	EQUIP	425	5	190	10	0.18	2	600
300	INST	423	5	190	10	0.18	2	600
301	COMP	421C	3	132	10	0.12	2	300
302	GRR	428	12	235	5	0.06	4	800
304	GRR	424	12	235	5	0.06	4	800
305	OFFICE	422	1	150	5	0.06	4	400
306	EQUIP	421	6	226	10	0.18	2	600



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307	ELEVATOR LOBBY	F402		506	5	0.06	N/A	100
308	SYNTHETIC CHEM	421A	6	994	10	0.18	2	6300
309	SYNTHETIC CHEM	420A	6	994	10	0.18	2	6150
310	SYNTHETIC CHEM	419A	6	994	10	0.18	3	7175
311	WOMEN'S LAVATORY	R421	N/A	180	N/A	N/A	2	100
312	MEN'S LAVATORY	R420	N/A	180	N/A	N/A	2	100
313	EQUIP	420	5	190	10	0.18	2	600
318	THEORIST WORK AREA	401C	10	390	5	0.06	4	800
319	THEORIST WORK AREA	401B	10	380	5	0.06	4	1000
320	GRR	401E	10	202	5	0.06	4	250
321	COMP	401D	2	90	5	0.06	4	300
322	THEORIST SUITE	401	N/A	204	N/A	0.06	4	200
323	OFFICE	401A	1	262	5	0.06	4	375
324	MEDIUM INSTRUMENT LAB	403	14	576	10	0.18	3	1300
325	MEDIUM INSTRUMENT LAB	405	13	512	10	0.18	3	1375
326	OFFICE	402	1	168	5	0.06	4	275
327	OFFICE	404	1	138	5	0.06	4	225
328	OFFICE	406	1	138	5	0.06	4	225
329	OFFICE	407	1	138	5	0.06	4	225
330	OFFICE	408	1	138	5	0.06	4	225
331	GRR	410	11	228	5	0.06	4	450
332	MEDIUM INSTRUMENT LAB	409	13	504	10	0.18	3	1000
333	HOOD ALCOVE	409A	N/A	72	N/A	N/A	3	225
334	MEDIUM INSTRUMENT LAB	411	13	504	10	0.18	3	1000
335	COMP	411A	2	72	10	0.12	3	150
336	SMALL INSTRUMENT LAB	411B	5	216	10	0.18	3	800
337	UTILITY TANK	411C	N/A	72	N/A	N/A	3	1000
338	LARGE INSTRUMENT LAB	415	22	878	10	0.18	3	1500
339	OFFICE	412	1	138	5	0.06	4	225
340	OFFICE	413	1	138	5	0.06	4	225
341	OFFICE	414	1	138	5	0.06	4	225
342	OFFICE	416	1	138	5	0.06	4	225
343	OFFICE	417	1	138	5	0.06	4	225
344	LOUNGE	418	32	318	7.5	0.18	4	675
345	CORR	Q403	N/A	948	N/A	0.06	4	1000
346	CORR	Q401	N/A	252	N/A	0.06	4	1600
347	CORR	Q402	N/A	740	N/A	0.06	4	650
348	STAIR LOBBY	F401	4	406	5	0.06	4	400
349	WEST STAIR	Z403	N/A	N/A	N/A	N/A	N/A	N/A
350	SOUTH STAIR	Z402	N/A	N/A	N/A	N/A	N/A	N/A

5TH FLOOR								
351	LOUNGE	539	17	174	7.5	0.18	4	800
352	OFFICE	537	1	150	5	0.06	4	400
353	OFFICE	535	1	150	5	0.06	4	400
354	OFFICE	534	1	150	5	0.06	4	400
355	OFFICE	533	1	150	5	0.06	4	400
356	OFFICE	531	1	150	5	0.06	4	400
357	GRR	529	12	235	5	0.06	4	800
358	SYNTHETIC CHEM	538A	6	994	10	0.18	1	5925



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359	SYNTHETIC CHEM	532B	4	665	10	0.18	1	4950
360	EQUIP	538	5	190	10	0.18	1	600
361	INST	536	5	190	10	0.18	1	600
362	COMP	532C	5	190	5	0.06	1	450
363	EQUIP	532	6	242	10	0.18	1	600
364	INST	530	3	130	10	0.18	1	400
366	INST	527D	5	190	10	0.18	1	600
367	COMP	527E	3	130	10	0.12	1	300
368	SYNTHETIC CHEM	532A	4	665	10	0.18	1	4625
369	SYNTHETIC CHEM	527C	4	665	10	0.18	1	4525
370	EQUIP	527	6	242	10	0.18	1	600
371	INST	527A	5	190	10	0.18	1	600
373	EQUIP	524	5	190	10	0.18	2	600
374	OFFICE	528	1	150	5	0.06	4	400
375	OFFICE	526	1	150	5	0.06	4	400
376	GRR	525	12	235	5	0.06	4	800
377	OFFICE	523	1	150	5	0.06	4	400
378	GRR	521	12	235	5	0.06	4	400
379	OFFICE	520	1	150	5	0.06	4	400
380	INST	522	5	190	10	0.18	2	600
381	INST	519C	3	130	10	0.18	2	450
382	EQUIP	519	6	242	10	0.18	2	600
383	ELEVATOR LOBBY	F502	2	222	5	0.06	N/A	100
384	SYNTHETIC CHEM	527B	4	665	10	0.18	1	4850
385	SYNTHETIC CHEM	524A	4	665	10	0.18	2	4175
387	SYNTHETIC CHEM	519A	6	994	10	0.18	2	5825
388	SYNTHETIC CHEM	518A	6	994	10	0.18	3	5825
389	WOMEN'S LAVATORY	R519	N/A	180	N/A	N/A	3	200
390	MEN'S LAVATORY	R518	N/A	180	N/A	N/A	3	200
391	EQUIP	518	5	190	10	0.18	3	600
395	CONFERENCE	501	16	320	5	0.06	4	450
397	MEDIUM INSTRUMENT LAB	503	14	550	10	0.18	3	1500
398	GRR	504	11	228	10	0.18	4	450
399	SMALL INSTRUMENT LAB	505	4	176	10	0.18	3	750
400	OFFICE	506	1	150	5	0.06	4	225
401	SMALL INSTRUMENT LAB	507	4	176	10	0.18	3	750
402	OFFICE	508	1	150	5	0.06	4	225
403	OFFICE	509	1	150	5	0.06	4	225
404	MEDIUM INSTRUMENT LAB	510	14	550	10	0.18	3	1500
405	OFFICE	511	1	150	5	0.06	4	225
406	OFFICE	512	1	150	5	0.06	4	225
407	OFFICE	514	1	150	5	0.06	4	225
408	SMALL INSTRUMENT LAB	513	5	184	10	0.18	3	750
409	GRR	516	11	228	5	0.06	4	450
410	MEDIUM INSTRUMENT LAB	515	14	550	10	0.18	3	1500
411	LOUNGE	517	25	252	7.5	0.18	4	450
412	CORR	Q501	N/A	726	N/A	0.06	4	750
413	CORR	Q502	N/A	918	N/A	0.06	4	1125
414	STAIR LOBBY	F501	6	576	5	0.06	N/A	N/A
415	WEST STAIR	Z503	N/A	N/A	N/A	N/A	N/A	N/A



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**VARIABLES & FORMULAS**

<b>ADDENDUM 'N' VARIABLES</b>	
<b>A<sub>Z</sub></b>	Zone Floor Area
<b>P<sub>Z</sub></b>	Zone Population
<b>R<sub>P</sub></b>	Outdoor Airflow Rate Required Per Person
<b>R<sub>A</sub></b>	Outdoor Airflow Rate Required Per Area
<b>E<sub>Z</sub></b>	Zone Air Distribution Effectiveness
<b>V<sub>OZ</sub></b>	Outdoor Airflow To Zone Corrected For Zone Air Distribution Effectiveness
<b>V<sub>PZ</sub></b>	Primary Airflow To Zone From Air Handler
<b>V<sub>PZM</sub></b>	Minimum Value Of The Primary Airflow TO Zone From Air Handler
<b>Z<sub>P</sub></b>	Primary Outdoor Air Fraction
<b>P<sub>S</sub></b>	System Population, Maximum Simultaneous # Of Occupants Of Space Peak Occupancies
<b>D</b>	Occupant Diversity, Ratio Of System Peak Occupancy To Sum Of Space Peak Occupancies
<b>V<sub>OU</sub></b>	Uncorrected Outdoor Air Intake
<b>X<sub>S</sub></b>	Mixing Ratio At Primary Air Handler Of Uncorrected Outdoor Air Intake To System Primary Flow
<b>Z<sub>P</sub> MAX</b>	Maximum Primary Outdoor Air Fraction Of All The Zones
<b>E<sub>V</sub></b>	System Ventilation Efficiency
<b>V<sub>OT</sub></b>	Minimum Outdoor Intake

<b>ADDENDUM 'N' EQUATIONS</b>
$V_{OZ} = (P_Z * R_P + A_Z * R_A) / E_Z$
$Z_P = V_{OZ} / V_{PZM}$
$D = P_S / \sum P_Z$
$V_{OU} = D * \sum (R_P * P_Z) + \sum (R_A * \sum A_Z)$
$X_S = V_{OU} / \sum V_{PZ}$
$V_{OT} = V_{OU} / E_V$







**BUILDING ZONES**

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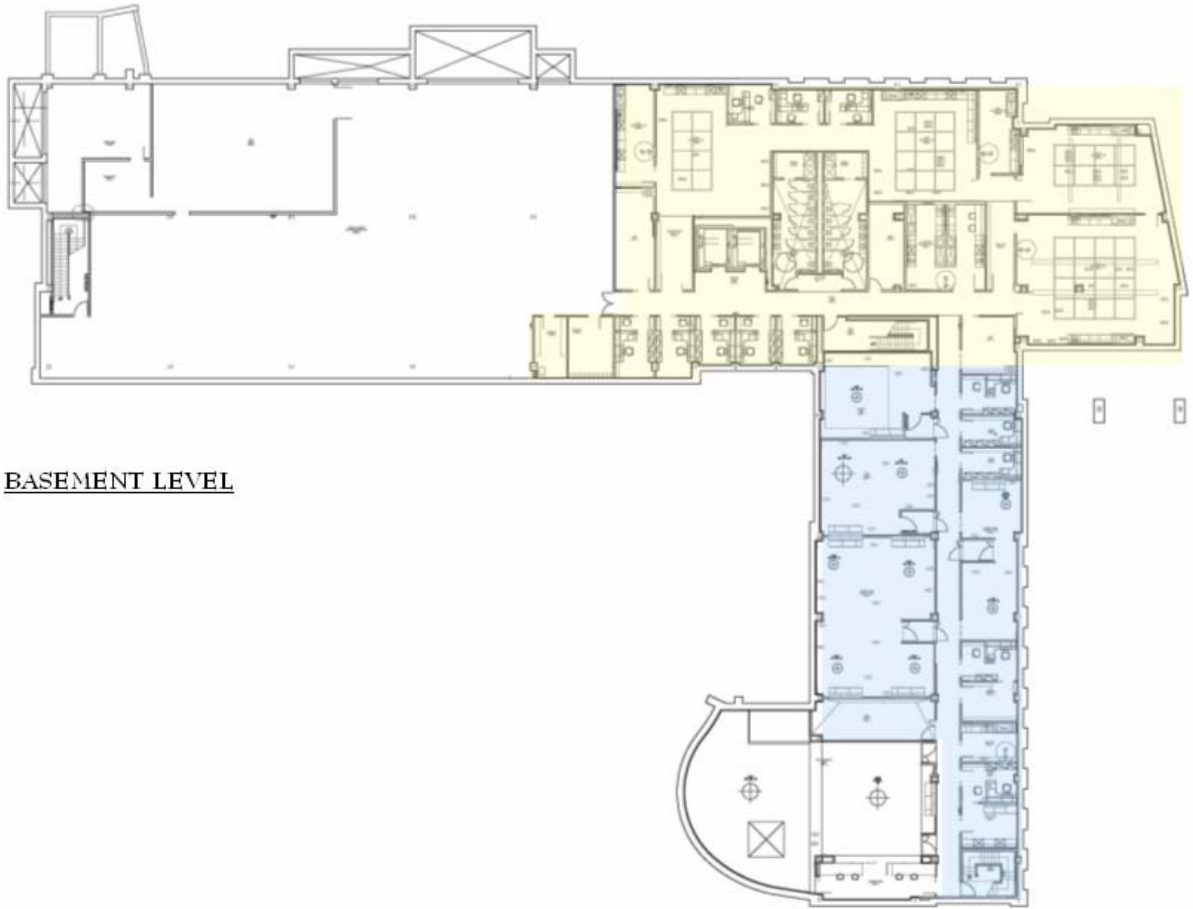
The building is split into four major zones per floor, except for the basement which is split into two major zones. Each of the zones is fed by one air handler. Laboratories are fed by air handlers 1-3, while offices are fed by air handler 4. All of the laboratories are on a constant air volume system with an outdoor air making up 100% of the supply air. Offices are fed by a variable air volume system with outdoor making up 100% of supply air. All air handlers are located in the mechanical penthouse.

The following floor plans illustrate the location of the zones throughout the building.

	CFM	OA	MANUF.	TYPE	LOCATION	COLOR
<b>AHU-1</b>	90000	90000	CARRIER	CV	PENTHOUSE	
<b>AHU-2</b>	100000	100000	CARRIER	CV	PENTHOUSE	
<b>AHU-3</b>	72500	72500	CARRIER	CV	PENTHOUSE	
<b>AHU-4</b>	72000	72000	CARRIER	VV	PENTHOUSE	



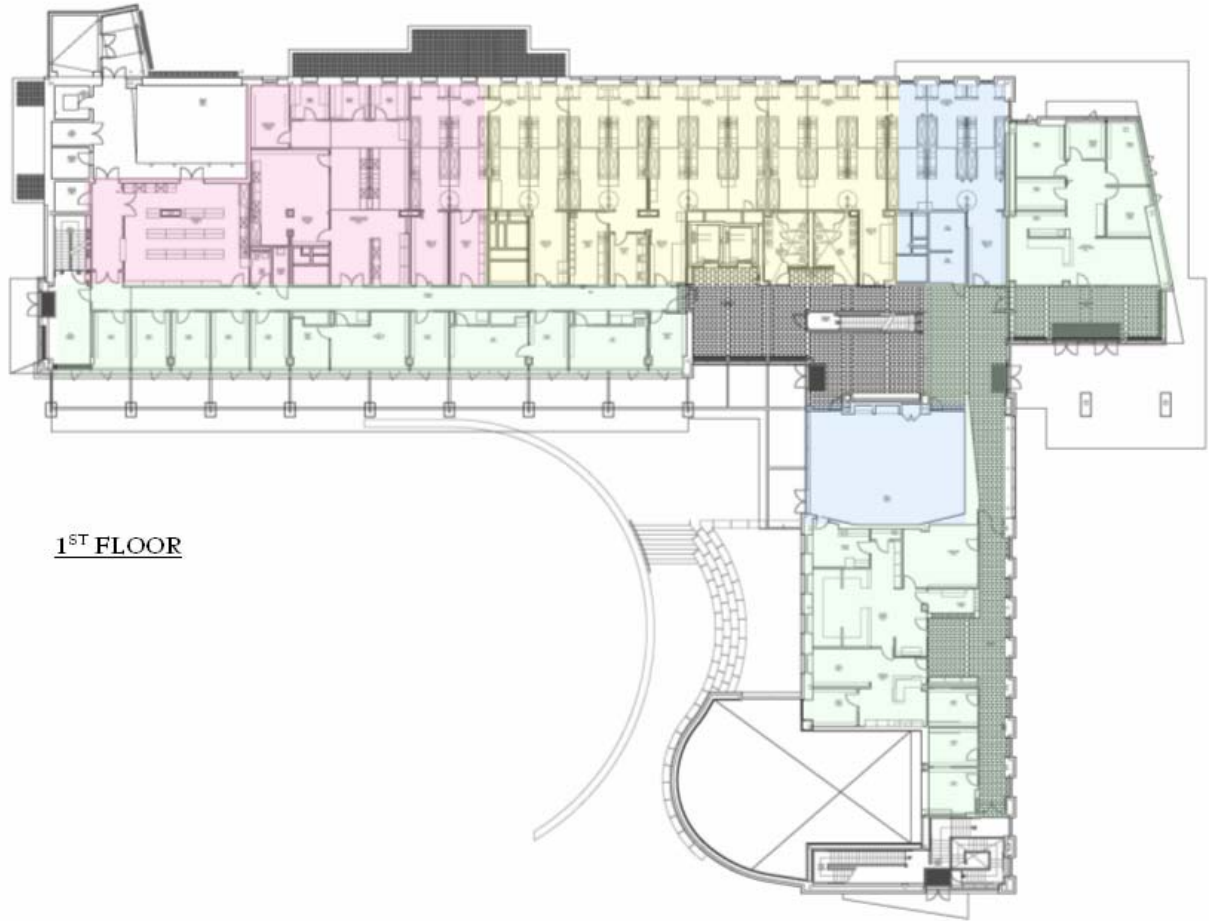
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BASEMENT LEVEL



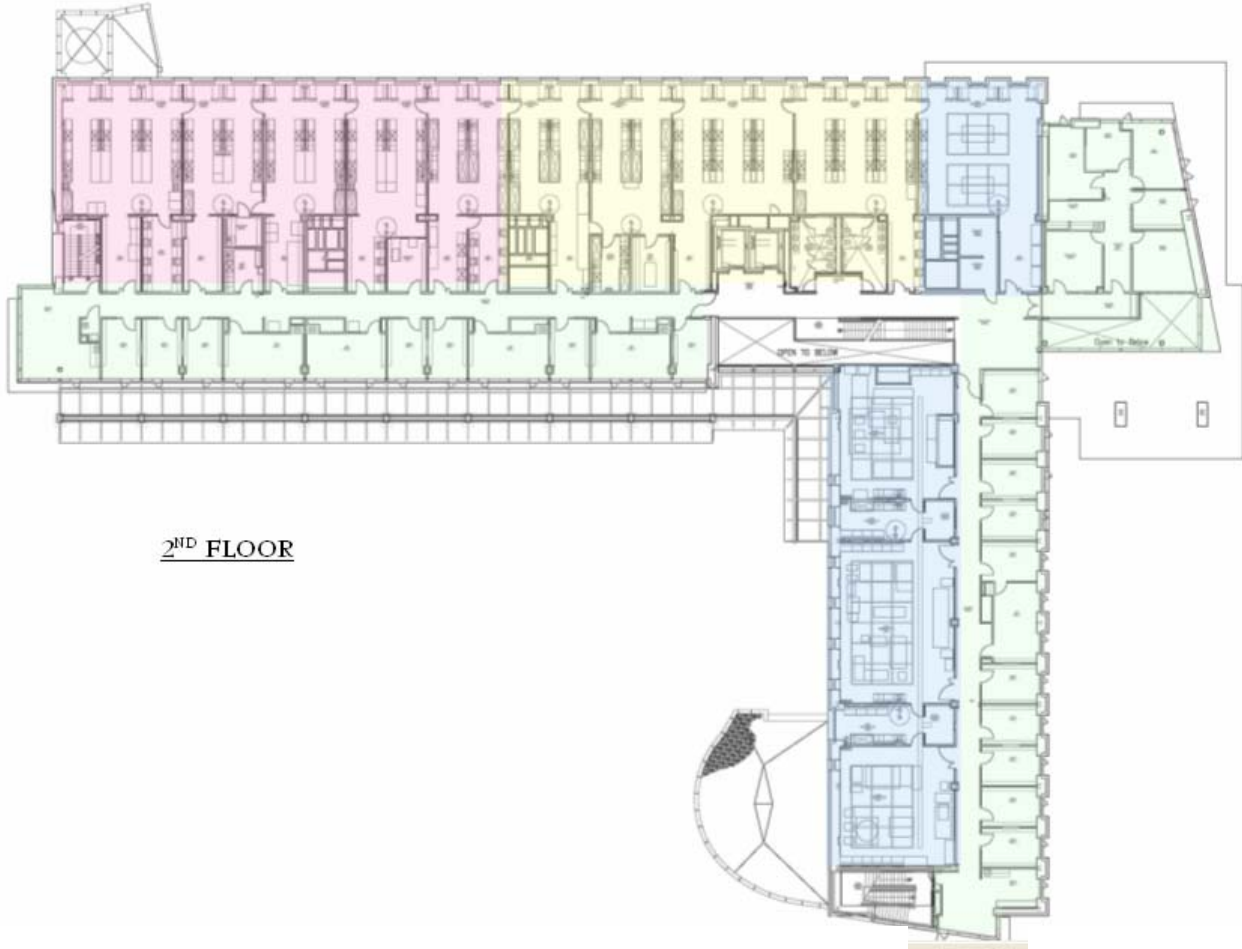
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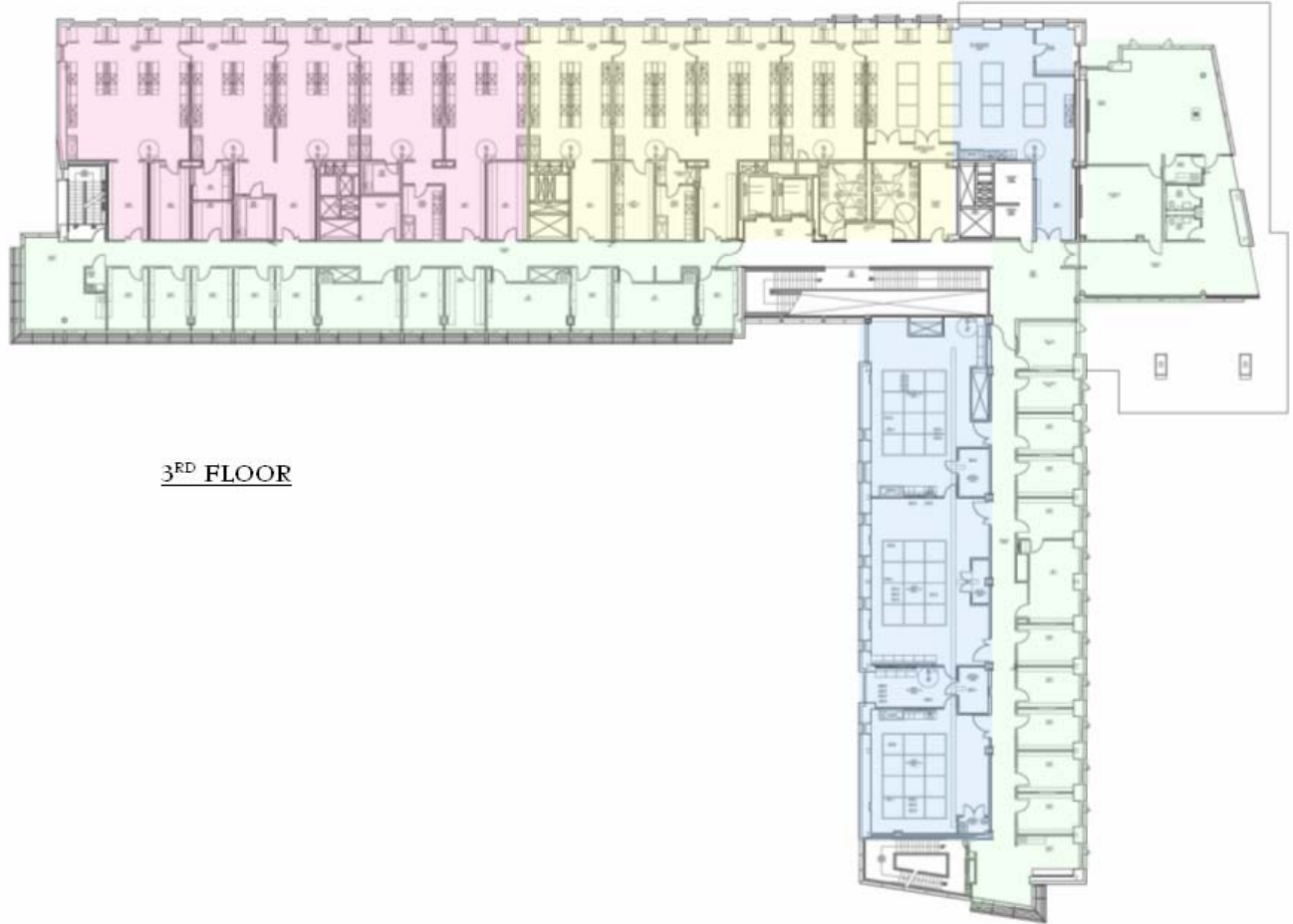
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2<sup>ND</sup> FLOOR



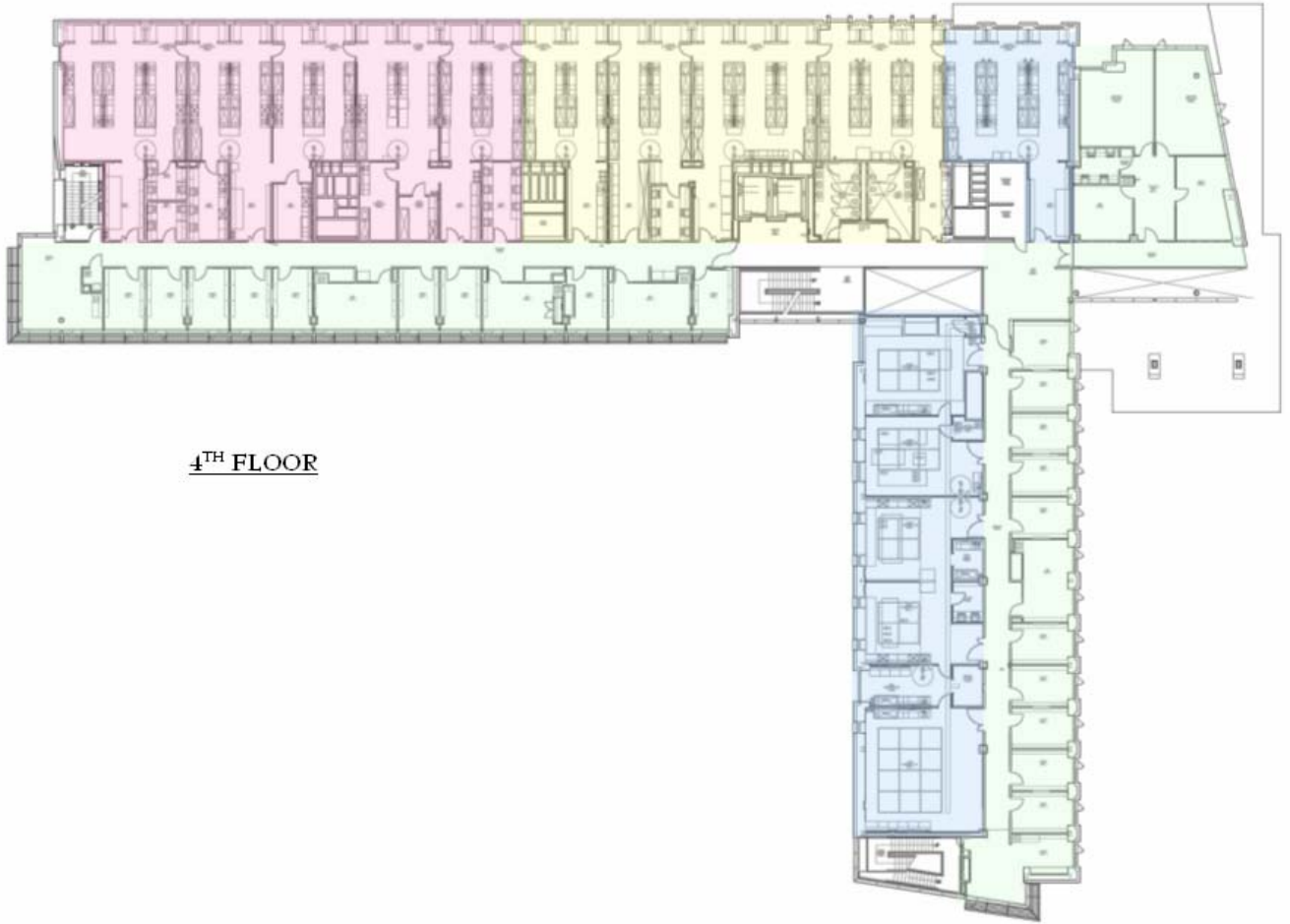
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3<sup>RD</sup> FLOOR



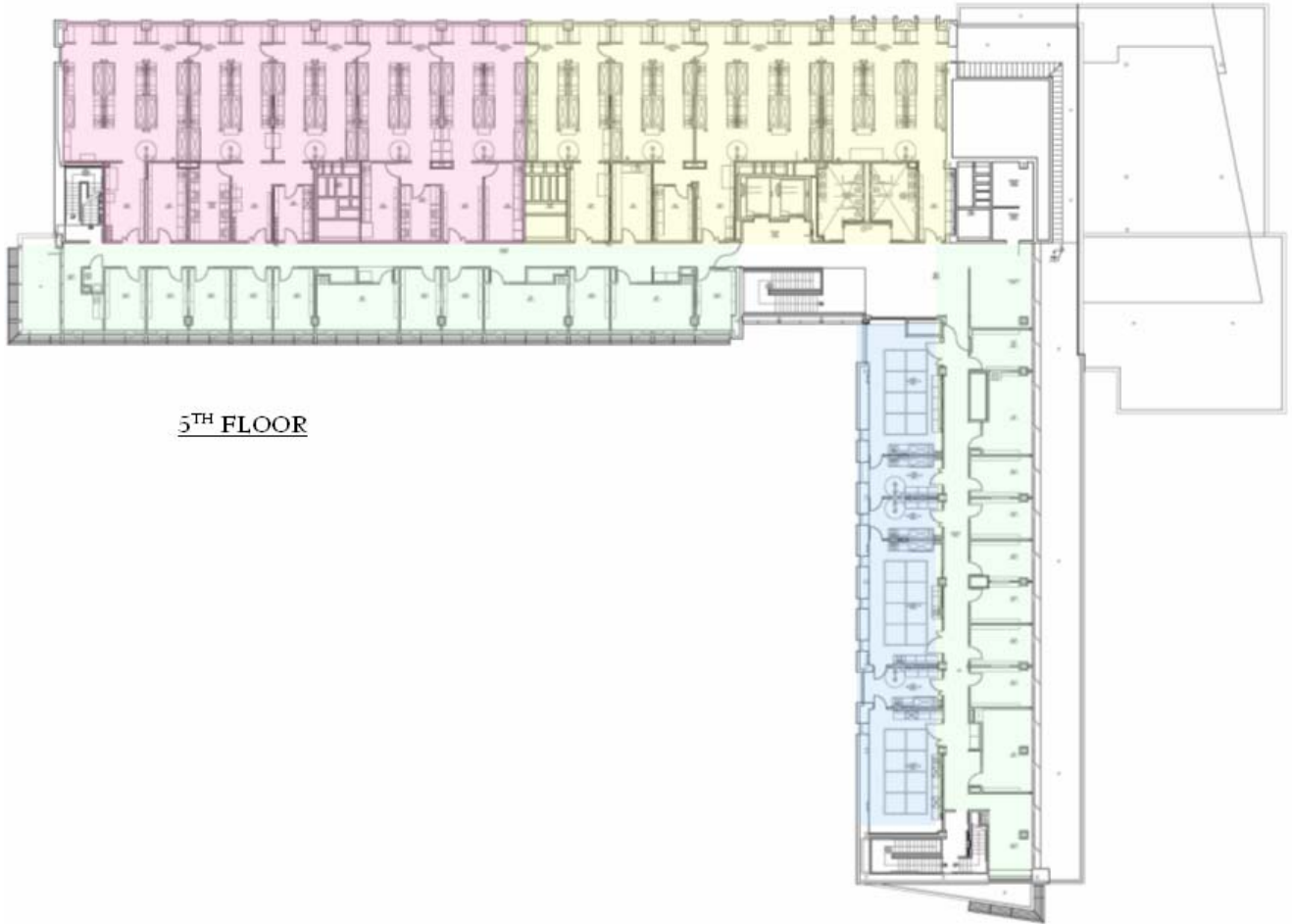
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4<sup>TH</sup> FLOOR



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5<sup>TH</sup> FLOOR



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## CALCULATIONS

<u>ZONE</u>	<u>SPACE</u>	<u>P<sub>Z</sub></u>	<u>A<sub>Z</sub></u>	<u>R<sub>P</sub></u>	<u>R<sub>A</sub></u>	<u>V<sub>PZ</sub></u>	<u>V<sub>OZ</sub></u>	<u>V<sub>PZM</sub></u>	<u>Z<sub>P</sub></u>	<u>P<sub>S</sub></u>	<u>V<sub>OU</sub></u>
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<b>AHU-1</b>												
49	RECEIVING AND STOCKROOM	125	N/A	1054	N/A	0.12	1200	126.48	0	0.00	281	0
56	MECHANICAL SHOP ROOM	121B	10	506	10	0.12	1300	161.92	101.2	0.12	281	161.92
57	SUPERVISOR'S OFFICE	121A	1	160	5	0.06	400	13.60	4	0.03	281	13.6
58	OFFICE	121C	1	86	5	0.06	275	10.16	5	0.04	281	10.16
59	OFFICE	121D	1	86	5	0.06	275	10.16	5	0.04	281	10.16
60	OFFICE	121E	1	86	5	0.06	275	10.16	5	0.04	281	10.16
61	ELECTRONIC SHOP	121	19	938	10	0.12	1400	300.16	187.6	0.21	281	300.16
63	SYNTHETIC LAB	117A	4	650	10	0.18	3825	157.00	40	0.04	281	157
67	EQUIP ROOM	119	5	186	10	0.18	600	79.98	46.5	0.13	281	79.98
68	INSTRUMENT ROOM	117	5	186	10	0.18	600	79.98	46.5	0.13	281	79.98
114	EQUIP	241	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
115	BIO CHEM LAB	241A	6	994	10	0.18	2250	238.92	60	0.11	281	238.92
116	COMP	241B	5	190	10	0.12	450	70.30	47.5	0.16	281	70.3
117	BIO CHEM LAB	239A	4	665	10	0.18	600	159.70	40	0.27	281	159.7
118	EQUIP	239	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
120	DARK ROOM	237	N/A	106	N/A	0.50	300	53.00	0	0.18	281	0
123	BIO CHEM LAB	235A	4	665	10	0.18	1500	159.70	40	0.11	281	159.7
124	EQUIP	235	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
128	BIO CHEM LAB	233A		665	10	0.18	1500	119.70	0	0.08	281	119.7
129	COMP	233	5	190	10	0.12	450	70.30	47.5	0.16	281	70.3
130	AUTOCLAVE	231	N/A	150	N/A	0.18	500	27.00	0	0.05	281	0
132	SYNTHETIC CHEM	229A	4	665	10	0.18	3825	159.70	40	0.04	281	159.7
133	EQUIP	229	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
134	COMP	227	5	190	10	0.12	450	70.30	47.5	0.16	281	70.3
192	BIO CHEM	335A	6	994	10	0.18	2250	238.92	60	0.11	281	238.92
193	BIO CHEM	331A	4	665	10	0.18	1500	159.70	40	0.11	281	159.7
194	BIO CHEM	331B	4	665	10	0.18	1500	159.70	40	0.11	281	159.7
195	EQUIP	335	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
196	COMP	335B	5	190	10	0.12	450	70.30	47.5	0.16	281	70.3
197	INST	331C	2	78	10	0.18	600	33.54	19.5	0.06	281	33.54
198	COMP	335C	3	107	10	0.12	600	39.59	26.75	0.07	281	39.59
206	EQUIP	331	7	264	10	0.18	900	113.52	66	0.13	281	113.52
207	BIO CHEM	327C	4	665	10	0.18	1500	159.70	40	0.11	281	159.7
208	BIO CHEM	327A	4	665	10	0.18	1500	159.70	40	0.11	281	159.7
212	TISSUE CULTURE	327B	3	134	10	0.18	450	57.62	33.5	0.13	281	57.62
215	EQUIP	327	6	240	10	0.18	750	103.20	60	0.14	281	103.2
218	COMP	325	5	190	10	0.12	450	70.30	47.5	0.16	281	70.3
273	EQUIP	439	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
276	COMP	437	2	90	10	0.12	225	33.30	22.5	0.15	281	33.3
277	INST	435D	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
278	EQUIP	435	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
280	COMP	439B	2	90	10	0.12	225	33.30	22.5	0.15	281	33.3



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281	SYNTHETIC CHEM	439A	6	994	10	0.18	6800	238.92	60	0.04	281	238.92
282	SYNTHETIC CHEM	435C	4	665	10	0.18	4950	159.70	40	0.03	281	159.7
283	SYNTHETIC CHEM	435B	4	665	10	0.18	5550	159.70	40	0.03	281	159.7
284	SYNTHETIC CHEM	429B	4	665	10	0.18	1500	159.70	40	0.11	281	159.7
285	INST	434A	3	132	10	0.18	400	56.76	33	0.14	281	56.76
291	EQUIP	429	7	272	10	0.18	300	116.96	68	0.39	281	116.96
292	TISSUE CULTURE	429D	3	106	10	0.18	350	45.58	26.5	0.13	281	45.58
293	RADIO ISOTOPE LAB	429C	5	190	10	0.18	800	81.70	47.5	0.10	281	81.7
294	SYNTHETIC CHEM	429A	4	665	10	0.18	4375	159.70	40	0.04	281	159.7
297	COMP	427	5	190	10	0.12	300	70.30	47.5	0.23	281	70.3
358	SYNTHETIC CHEM	538A	6	994	10	0.18	5925	238.92	60	0.04	281	238.92
359	SYNTHETIC CHEM	532B	4	665	10	0.18	4950	159.70	40	0.03	281	159.7
360	EQUIP	538	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
361	INST	536	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
362	COMP	532C	5	190	5	0.06	450	35.15	23.75	0.08	281	35.15
363	EQUIP	532	6	242	10	0.18	600	104.06	60.5	0.17	281	104.06
364	INST	530	3	130	10	0.18	400	55.90	32.5	0.14	281	55.9
366	INST	527D	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
367	COMP	527E	3	130	10	0.12	300	48.10	32.5	0.16	281	48.1
368	SYNTHETIC CHEM	532A	4	665	10	0.18	4625	159.70	40	0.03	281	159.7
369	SYNTHETIC CHEM	527C	4	665	10	0.18	4525	159.70	40	0.04	281	159.7
370	EQUIP	527	6	242	10	0.18	600	104.06	60.5	0.17	281	104.06
371	INST	527A	5	190	10	0.18	600	81.70	47.5	0.14	281	81.7
384	SYNTHETIC CHEM	527B	4	665	10	0.18	4850	159.70	40	0.03	281	159.7
							90000					6758.5

$X_s$	0.0751	$E_v$	0.5
MAX $Z_p$	0.39	$V_{OT}$	13517
$D$	1		

### AHU-1

Air handler 1 is a constant air volume unit which feeds laboratory spaces. The unit contains particulate filters, preheat, reheat and cooling coils, supply and return fans. It is located in the mechanical penthouse of the building. The AHU supplies 90,000 CFM to the designated spaces. The supply is made up of 100% outdoor air. The design minimum outdoor airflow is 13,512 CFM to the spaces. This is equivalent to about 15% of the total CFM supplied. Since the unit uses 100% outdoor air, it well exceeds the requirements set by ASHRAE Addendum 'n'.



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<u>ZONE</u>	<u>SPACE</u>	<u>P<sub>Z</sub></u>	<u>A<sub>Z</sub></u>	<u>R<sub>P</sub></u>	<u>R<sub>A</sub></u>	<u>V<sub>PZ</sub></u>	<u>V<sub>OZ</sub></u>	<u>V<sub>PZM</sub></u>	<u>Z<sub>P</sub></u>	<u>P<sub>S</sub></u>	<u>V<sub>OU</sub></u>
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<b>AHU-2</b>												
1	SMALL INSTRUMENT LAB	023B	8	256	10	0.18	575	122.88	76.8	0.21	337	122.88
2	GRR	025	13	256	5	0.06	500	79.36	64	0.16	337	79.36
3	MEDIUM INSTRUMENT LAB	023A	29	952	10	0.18	1550	456.96	285.6	0.29	337	456.96
4	INSTRUMENT RM	023	5	177	10	0.18	600	84.96	53.1	0.14	337	84.96
5	OFFICE	026	2	154	5	0.06	150	19.24	10	0.13	337	19.24
6	OFFICE	024	2	154	5	0.06	150	19.24	10	0.13	337	19.24
7	OFFICE	022	2	120	5	0.06	125	17.20	10	0.14	337	17.2
8	OFFICE	021	2	120	5	0.06	125	17.20	10	0.14	337	17.2
9	OFFICE	020	2	120	5	0.06	125	17.20	10	0.14	337	17.2
10	OFFICE	023C	2	116	5	0.06	125	16.96	10	0.14	337	16.96
11	OFFICE	023E	1	102	5	0.06	125	8.67	2.55	0.07	337	8.67
12	OFFICE	023F	1	102	5	0.06	125	8.67	2.55	0.07	337	8.67
13	MEN'S LAVATORY	R020	N/A	362	N/A	N/A	400	0.00	0	0.00	337	0
14	WOMEN'S LAVATORY	R019	N/A	362	N/A	N/A	400	0.00	0	0.00	337	0
15	LARGE INSTRUMENT LAB	018C	26	867	10	0.18	1800	416.16	260.1	0.23	337	416.16
18	SMALL INSTRUMENT LAB	018B	6	214	10	0.18	525	102.72	64.2	0.20	337	102.72
19	LARGE INSTRUMENT LAB	018A	24	784	10	0.18	1350	376.32	235.2	0.28	337	376.32
20	JUMBO INSTRUMENT LAB	017	39	1314	10	0.18	2600	630.72	394.2	0.24	337	630.72
34	ENTRYWAY	018	1	224	5	0.06	400	19.04	5.6	0.05	337	19.04
39	CORRIDOR	0001	N/A	411	N/A	0.06	250	24.66	0	0.10	337	24.66
64	SYNTHETIC LAB	115A	4	650	10	0.18	5050	157.00	40	0.03	337	157
65	SYNTHETIC LAB	113A	4	650	10	0.18	5450	157.00	40	0.03	337	157
66	SYNTHETIC LAB	111A	6	977	10	0.18	6300	235.86	60	0.04	337	235.86
69	EQUIP ROOM	115	5	186	10	0.18	600	79.98	46.5	0.13	337	79.98
70	INSTRUMENT ROOM	113B	5	186	10	0.18	600	79.98	46.5	0.13	337	79.98
71	COMPUTER ROOM	113	3	120	10	0.12	450	44.40	30	0.10	337	44.4
72	EQUIP ROOM	111	4	178	10	0.18	600	76.54	44.5	0.13	337	76.54
79	SYNTHETIC LAB	110A	6	977	10	0.18	6750	235.86	60	0.03	337	235.86
81	WOMEN'S LAVATORY	R111	N/A	180	N/A	N/A	150	0.00	0	0.00	337	0
82	MEN'S LAVATORY	R110	N/A	180	N/A	N/A	150	0.00	0	0.00	337	0
83	EQUIP ROOM	110	4	170	10	0.18	600	73.10	42.5	0.12	337	73.1
138	EQUIP	225	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
139	SYNTHETIC CHEM	225A	4	665	10	0.18	4200	159.70	40	0.04	337	159.7
141	SYNTHETIC CHEM	219B	4	665	10	0.18	4475	159.70	40	0.04	337	159.7
142	TISSUE CULTURE	223	3	136	10	0.18	450	58.48	34	0.13	337	58.48
143	LASER ROOM	221	3	136	10	0.18	400	58.48	34	0.15	337	58.48
145	BIO CHEM LAB	219A	4	994	10	0.18	2250	218.92	40	0.10	337	218.92
146	EQUIP	219	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
149	BIO CHEM LAB	218A	6	994	10	0.18	2250	238.92	60	0.11	337	238.92
150	EQUIP	218	4	168	10	0.12	600	62.16	42	0.10	337	62.16
151	WOMEN'S LAVATORY	R218	N/A	180	N/A	N/A	150	0.00	0	0.00	337	0
152	MEN'S LAVATORY	R217	N/A	180	N/A	N/A	150	0.00	0	0.00	337	0
221	BIO CHEM	323A	4	665	10	0.12	1500	119.80	40	0.08	337	119.8



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222	BIO CHEM	318B	4	665	10	0.12	1500	119.80	40	0.08	337	119.8
223	EQUIP	323	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
225	ANATOMY LAB	318D	1	48	10	0.18	150	20.64	12	0.14	337	20.64
226	RADIO ISOTOPE LAB	318C	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
228	TISSUE CULTURE	320	3	130	10	0.18	450	55.90	32.5	0.12	337	55.9
230	COMP	318	5	190	10	0.12	600	70.30	47.5	0.12	337	70.3
231	BIO CHEM	318A	4	665	10	0.18	1500	159.70	40	0.11	337	159.7
232	MASS SPEC PREP LAB	317C	17	665	10	0.18	1500	285.95	166.25	0.19	337	285.95
296	SYNTHETIC CHEM	423A	4	665	10	0.18	3825	159.70	40	0.04	337	159.7
299	EQUIP	425	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
300	INST	423	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
301	COMP	421C	3	132	10	0.12	300	48.84	33	0.16	337	48.84
306	EQUIP	421	6	226	10	0.18	600	97.18	56.5	0.16	337	97.18
308	SYNTHETIC CHEM	421A	6	994	10	0.18	6300	238.92	60	0.04	337	238.92
309	SYNTHETIC CHEM	420A	6	994	10	0.18	6150	238.92	60	0.04	337	238.92
311	WOMEN'S LAVATORY	R421	N/A	180	N/A	N/A	100	0.00	0	0.00	337	0
312	MEN'S LAVATORY	R420	N/A	180	N/A	N/A	100	0.00	0	0.00	337	0
313	EQUIP	420	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
373	EQUIP	524	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
380	INST	522	5	190	10	0.18	600	81.70	47.5	0.14	337	81.7
381	INST	519C	3	130	10	0.18	450	55.90	32.5	0.12	337	55.9
382	EQUIP	519	6	242	10	0.18	600	104.06	60.5	0.17	337	104.06
385	SYNTHETIC CHEM	524A	4	665	10	0.18	4175	159.70	40	0.04	337	159.7
386	SYNTHETIC CHEM	519B	4	665	10	0.18	4575	159.70	40	0.03	337	159.7
387	SYNTHETIC CHEM	519A	6	994	10	0.18	5825	238.92	60	0.04	337	238.92
							100000					7763.2

$X_s$	0.0776	$E_v$	0.5
$MAX Z_p$	0.29	$V_{OT}$	15526
$D$	1		

## AHU-2

Air handler 2 is a constant air volume unit which feeds laboratory spaces. The unit contains particulate filters, preheat, reheat and cooling coils, supply and return fans. It is located in the mechanical penthouse of the building. The AHU supplies 100,000 CFM to the designated spaces. The supply is made up of 100% outdoor air. The design minimum outdoor airflow is 15,526 CFM to the spaces. This is equivalent to about 16% of the total CFM supplied. Since the unit uses 100% outdoor air, it well exceeds the requirements set by ASHRAE Addendum 'n'.





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<u>ZONE</u>	<u>SPACE</u>	<u>P<sub>Z</sub></u>	<u>A<sub>Z</sub></u>	<u>R<sub>P</sub></u>	<u>R<sub>A</sub></u>	<u>V<sub>PZ</sub></u>	<u>V<sub>OZ</sub></u>	<u>V<sub>PZM</sub></u>	<u>Z<sub>P</sub></u>	<u>P<sub>S</sub></u>	<u>V<sub>OU</sub></u>
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<b>AHU-3</b>												
17	SYNTHETIC CHEM	019	4	444	10	0.18	1000	119.92	40	0.12	587	119.92
21	GRR	001	10	200	5	0.06	300	62.00	50	0.21	587	62
22	FACULTY NMR	003	18	608	10	0.18	1000	291.84	182.4	0.29	587	291.84
23	OFFICE	002	2	140	5	0.06	125	18.40	10	0.15	587	18.4
24	OFFICE	004	1	140	5	0.06	125	13.40	5	0.11	587	13.4
25	OFFICE	005	1	140	5	0.06	125	13.40	5	0.11	587	13.4
26	NMR SOLIDS	007	21	706	10	0.18	500	338.88	211.8	0.68	587	338.88
27	GENERAL NMR	006	16	544	10	0.18	3300	261.12	163.2	0.08	587	261.12
28	GENERAL NMR	009	35	1178	10	0.18	6000	565.44	353.4	0.09	587	565.44
29	DIRECTOR'S OFFICE	008	2	144	5	0.06	150	18.64	10	0.12	587	18.64
30	NMR COMPUTER	010	4	144	10	0.12	400	53.28	36	0.13	587	53.28
31	UTILITY ROOM	011	2	325	10	0.18	900	78.50	20	0.09	587	78.5
32	PREP ROOM	012	4	142	10	0.18	575	68.16	42.6	0.12	587	68.16
33	TECHNICIANS OFFICE	014	2	142	5	0.06	150	18.52	10	0.12	587	18.52
35	ELEC. SHOP	016	3	164	10	0.18	250	62.32	32.8	0.25	587	62.32
38	STAIR LOBBY	F001	7	707	7.5	0.06	250	95.45	53.025	0.38	587	95.445
80	SYNTHETIC LAB	109A	6	977	10	0.18	7200	235.86	60	0.03	587	235.86
87	EQUIP ROOM	109	5	190	10	0.18	600	81.70	47.5	0.14	587	81.7
96	SEMINAR	102	80	1138	7.5	0.06	1200	668.28	600	0.56	587	668.28
154	INSTRUMENT LAB	217A	25	994	10	0.18	2250	427.42	248.5	0.19	587	427.42
157	EQUIP	217	5	212	10	0.18	600	91.16	53	0.15	587	91.16
167	LARGE INSTRUMENT LAB	204	22	872	10	0.18	1500	374.96	218	0.25	587	374.96
168	SMALL INSTRUMENT LAB	204A	5	208	10	0.18	800	89.44	52	0.11	587	89.44
169	JUMBO INSTRUMENT LAB	207	30	1180	10	0.18	1500	507.40	295	0.34	587	507.4
170	UTILITY TANK	204	N/A	72	N/A	0.12	100	8.64	0	0.09	587	8.64
178	SMALL INSTRUMENT LAB	207A	5	208	10	0.18	800	89.44	52	0.11	587	89.44
179	UTILITY TANK	207B	N/A	72	N/A	0.12	100	8.64	0	0.09	587	8.64
180	LARGE INSTRUMENT LAB	212	22	874	10	0.18	1500	375.82	218.5	0.25	587	375.82
233	MASS SPEC LAB AND SUPPORT	317A	38	1518	10	0.18	2975	652.74	379.5	0.22	587	652.74
235	WOMEN'S LAVATORY	R318	N/A	180	N/A	N/A	150	0.00	0	0.00	587	0
236	MEN'S LAVATORY	R317	N/A	180	N/A	N/A	150	0.00	0	0.00	587	0
241	EQUIP	317	5	190	10	0.18	600	81.70	47.5	0.14	587	81.7
242	OFFICE	317B	1	108	5	0.06	300	11.48	5	0.04	587	11.48
251	JUMBO INSTRUMENT LAB	304	27	1074	10	0.18	1900	461.82	268.5	0.24	587	461.82
254	JUMBO INSTRUMENT LAB	307	30	1180	10	0.18	1900	507.40	295	0.27	587	507.4
260	SMALL INSTRUMENT LAB	307A	5	208	10	0.18	5000	89.44	52	0.02	587	89.44
261	LARGE INSTRUMENT LAB	312	22	872	10	0.18	1500	374.96	218	0.25	587	374.96
310	SYNTHETIC CHEM	419A	6	994	10	0.18	7175	238.92	60	0.03	587	238.92
317	EQUIP	419	5	190	10	0.18	1200	81.70	47.5	0.07	587	81.7
324	MEDIUM INSTRUMENT LAB	403	14	576	10	0.18	1300	247.68	144	0.19	587	247.68
325	MEDIUM INSTRUMENT LAB	405	13	512	10	0.18	1375	220.16	128	0.16	587	220.16
332	MEDIUM INSTRUMENT LAB	409	13	504	10	0.18	1000	216.72	126	0.22	587	216.72
333	HOOD ALCOVE	409A	N/A	72	N/A	N/A	225	0.00	0	0.00	587	0



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334	MEDIUM INSTRUMENT LAB	411	13	504	10	0.18	1000	216.72	126	0.22	587	216.72	
335	COMP	411A	2	72	10	0.12	150	26.64	18	0.18	587	26.64	
336	SMALL INSTRUMENT LAB	411B	5	216	10	0.18	800	92.88	54	0.12	587	92.88	
337	UTILITY TANK	411C	N/A	72	N/A	0.12	100	8.64	0	0.09	587	8.64	
338	LARGE INSTRUMENT LAB	415	22	878	10	0.18	1500	377.54	219.5	0.25	587	377.54	
388	SYNTHETIC CHEM	518A	6	994	10	0.18	5825	238.92	60	0.04	587	238.92	
389	WOMEN'S LAVATORY	R519	N/A	180	N/A	N/A	200	0.00	0	0.00	587	0	
390	MEN'S LAVATORY	R518	N/A	180	N/A	N/A	200	0.00	0	0.00	587	0	
391	EQUIP	518	5	190	10	0.18	600	81.70	47.5	0.14	587	81.7	
397	MEDIUM INSTRUMENT LAB	503	14	550	10	0.18	1500	236.50	137.5	0.16	587	236.5	
399	SMALL INSTRUMENT LAB	505	4	176	10	0.18	750	75.68	44	0.10	587	75.68	
401	SMALL INSTRUMENT LAB	507	4	176	10	0.18	750	75.68	44	0.10	587	75.68	
404	MEDIUM INSTRUMENT LAB	510	14	550	10	0.18	1500	236.50	137.5	0.16	587	236.5	
408	SMALL INSTRUMENT LAB	513	5	184	10	0.18	750	79.12	46	0.11	587	79.12	
410	MEDIUM INSTRUMENT LAB	515	14	550	10	0.18	1500	236.50	137.5	0.16	587	236.5	
							72500						10206

$X_s$	0.1408	$E_v$	0.5
$MAX Z_p$	0.68	$V_{OT}$	20412
$D$	1		

### AHU-3

Air handler 2 is a constant air volume unit which feeds laboratory spaces. The unit contains particulate filters, preheat, reheat and cooling coils, supply and return fans. It is located in the mechanical penthouse of the building. The AHU supplies 72,500 CFM to the designated spaces. The supply is made up of 100% outdoor air. The design minimum outdoor airflow is 20,412 CFM to the spaces. This is equivalent to about 28% of the total CFM supplied. Since the unit uses 100% outdoor air, it well exceeds the requirements set by ASHRAE Addendum 'n'.



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<u>ZONE</u>	<u>SPACE</u>	<u>P<sub>Z</sub></u>	<u>A<sub>Z</sub></u>	<u>R<sub>P</sub></u>	<u>R<sub>A</sub></u>	<u>V<sub>PZ</sub></u>	<u>V<sub>OZ</sub></u>	<u>V<sub>PZM</sub></u>	<u>Z<sub>P</sub></u>	<u>P<sub>S</sub></u>	<u>V<sub>OU</sub></u>
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<b>AHU-4</b>												
43	WEST ENTRYWAY	Q103	3	308	5	0.06	750	33.88	15.4	0.05	775	33.88
50	OFFICE	128	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
51	OFFICE	127	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
52	OFFICE	126	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
53	OFFICE	124	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
54	OFFICE	123	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
55	SERVER ROOM	122A	1	126	5	0.06	500	10.71	3.15	0.02	775	10.71
50	OFFICE	128	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
51	OFFICE	127	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
52	OFFICE	126	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
53	OFFICE	124	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
54	OFFICE	123	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
55	SERVER ROOM	122A	1	126	5	0.06	500	10.71	3.15	0.02	775	10.71
62	RIF OFFICE SUITE	122	10	282	5	0.06	650	66.27	49.35	0.10	775	66.27
73	OFFICE	120	1	150	5	0.06	325	12.75	3.75	0.04	775	12.75
74	GRR	118	12	248	5	0.06	650	76.88	62	0.12	775	76.88
75	OFFICE	116	1	150	5	0.06	400	12.75	3.75	0.03	775	12.75
76	GRR	114	12	248	5	0.06	650	76.88	62	0.12	775	76.88
77	COMPUTER ROOM	112	4	142	10	0.12	325	52.54	35.5	0.16	775	52.54
78	MAIN ELEVATOR LOBBY	F102	22	2152	7.5	0.06	100	290.52	161.4	2.91	775	290.52
88	OFFICE	101D	1	168	5	0.06	250	14.28	4.2	0.06	775	14.28
89	OFFICE	101E	1	104	5	0.06	150	8.84	2.6	0.06	775	8.84
90	COPIER	101F	1	84	5	0.06	125	10.04	5	0.08	775	10.04
91	ACADEMIC AFFAIRS	101C	1	102	5	0.06	225	8.67	2.55	0.04	775	8.67
92	OFFICE	101B	1	150	5	0.06	425	12.75	3.75	0.03	775	12.75
93	ACADEMIC AFFAIRS	101A	1	144	5	0.06	225	12.24	3.6	0.05	775	12.24
94	ADADEMIC OFFICE	101	2	476	5	0.06	400	40.46	11.9	0.10	775	40.46
95	MAIN ENTRY VESTIBULE	Q101	6	642	7.5	0.06	1600	86.67	48.15	0.05	775	86.67
97	KITCHEN	104C	8	159	7.5	0.18	400	88.25	59.63	0.22	775	88.245
98	CONFERENCE	103	15	303	5	0.06	450	93.93	75.75	0.21	775	93.93
99	FACULTY SERVICES	104	5	642	5	0.06	600	63.52	25	0.11	775	63.52
100	MAILROOM	104A	1	79	5	0.06	100	9.74	5	0.10	775	9.74
101	GRADUATE RECRUITING	105	14	456	5	0.06	475	95.76	68.4	0.20	775	95.76
102	GRAD OFFICE	105A	1	128	5	0.06	150	10.88	3.2	0.07	775	10.88
103	OFFICE	106	1	128	5	0.06	125	10.88	3.2	0.09	775	10.88
104	OFFICE	107	1	128	5	0.06	125	10.88	3.2	0.09	775	10.88
105	OFFICE	108	1	152	5	0.06	125	12.92	3.8	0.10	775	12.92
107	CORRIDOR	Q102	N/A	736	N/A	0.06	1100	44.16	0	0.04	775	44.16
108	CORRIDOR	Q103	N/A	928	N/A	0.06	1025	55.68	0	0.05	775	55.68
112	LOUNGE	243	37	370	7.5	0.18	1100	344.10	277.5	0.31	775	344.1
113	OFFICE	242	1	150	5	0.06	400	14.00	5	0.04	775	14
121	OFFICE	240	1	150	5	0.06	400	14.00	5	0.04	775	14
122	OFFICE	238	1	150	5	0.06	400	14.00	5	0.04	775	14
126	GRR	234	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
127	GRR	232	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02



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131	OFFICE	230	1	150	5	0.06	400	14.00	5	0.04	775	14
135	OFFICE	228	1	150	5	0.06	400	14.00	5	0.04	775	14
136	GRR	226	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
140	OFFICE	224	1	150	5	0.06	400	14.00	5	0.04	775	14
144	GRR	222	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
147	OFFICE	220	1	150	5	0.06	400	14.00	5	0.04	775	14
159	OFFICE	201E	1	192	5	0.06	350	16.52	5	0.05	775	16.52
160	OFFICE	201D	1	126	5	0.06	350	12.56	5	0.04	775	12.56
161	OFFICE	201C	1	202	5	0.06	800	17.12	5	0.02	775	17.12
162	OFFICE	201B	1	130	5	0.06	275	12.80	5	0.05	775	12.8
163	THEORST SUITE	201	N/A	202	N/A	0.06	200	12.12	0	0.06	775	12.12
164	OFFICE	201A	1	228	5	0.06	250	18.68	5	0.07	775	18.68
165	COMPUTER	201F	3	102	10	0.12	300	37.74	25.5	0.13	775	37.74
166	CONFERENCE	201G	11	220	5	0.06	250	68.20	55	0.27	775	68.2
171	OFFICE	202	1	168	5	0.06	225	15.08	5	0.07	775	15.08
172	OFFICE	203	1	138	5	0.06	225	13.28	5	0.06	775	13.28
173	OFFICE	205	1	138	5	0.06	225	13.28	5	0.06	775	13.28
174	OFFICE	206	1	138	5	0.06	225	13.28	5	0.06	775	13.28
175	OFFICE	208	1	138	5	0.06	225	13.28	5	0.06	775	13.28
176	GRR	209	11	228	5	0.06	450	70.68	57	0.16	775	70.68
181	OFFICE	211	1	138	5	0.06	225	13.28	5	0.06	775	13.28
183	OFFICE	214	1	138	5	0.06	225	13.28	5	0.06	775	13.28
184	OFFICE	215	1	138	5	0.06	225	13.28	5	0.06	775	13.28
185	LOUNGE	216	32	318	7.5	0.18	675	295.74	238.5	0.44	775	295.74
186	CORRIDOR	Q203	N/A	948	N/A	0.06	1425	56.88	0	0.04	775	56.88
187	CORRIDOR	Q201	N/A	146	N/A	0.06	800	8.76	0	0.01	775	8.76
188	CORRIDOR	Q202	N/A	736	N/A	0.06	600	44.16	0	0.07	775	44.16
200	LOUNGE	337	37	370	7.5	0.18	1100	344.10	277.5	0.31	775	344.1
201	OFFICE	336	1	150	5	0.06	400	14.00	5	0.04	775	14
202	OFFICE	334	1	150	5	0.06	400	14.00	5	0.04	775	14
203	OFFICE	333	1	150	5	0.06	400	14.00	5	0.04	775	14
205	OFFICE	330	1	150	5	0.06	400	14.00	5	0.04	775	14
213	GRR	328	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
216	OFFICE	326	1	150	5	0.06	400	14.00	5	0.04	775	14
217	COMP	326A	4	150	10	0.12	600	55.50	37.5	0.09	775	55.5
219	GRR	324	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
224	OFFICE	322	1	150	5	0.06	400	14.00	5	0.04	775	14
229	OFFICE	319	1	150	5	0.06	400	14.00	5	0.04	775	14
243	SEMINAR	301A	42	844	7.5	0.06	1500	367.14	316.5	0.24	775	367.14
244	CONFERENCE	301	18	366	5	0.06	300	113.46	91.5	0.38	775	113.46
248	DEPT SEC	302	1	168	5	0.06	275	15.08	5	0.05	775	15.08
249	DEPT COPIER	303	1	138	5	0.06	225	13.28	5	0.06	775	13.28
250	OFFICE	305	1	138	5	0.06	225	13.28	5	0.06	775	13.28
252	OFFICE	306	1	138	5	0.06	225	13.28	5	0.06	775	13.28
253	OFFICE	308	1	138	5	0.06	225	13.28	5	0.06	775	13.28
257	GRR	309	11	226	10	0.18	450	153.68	113	0.34	775	153.68
258	OFFICE	310	1	138	5	0.06	225	13.28	5	0.06	775	13.28
259	OFFICE	311	1	138	5	0.06	225	13.28	5	0.06	775	13.28
262	OFFICE	313	1	138	5	0.06	225	13.28	5	0.06	775	13.28
263	OFFICE	314	1	138	5	0.06	225	13.28	5	0.06	775	13.28



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264	OFFICE	315	1	138	5	0.06	225	13.28	5	0.06	775	13.28
265	LOUNGE	316	32	318	7.5	0.18	675	295.74	238.5	0.44	775	295.74
266	CORR	Q303	N/A	968	N/A	0.06	925	58.08	0	0.06	775	58.08
267	CORR	Q301	N/A	750	N/A	0.06	1600	45.00	0	0.03	775	45
268	CORR	Q302	N/A	732	N/A	0.06	600	43.92	0	0.07	775	43.92
269	STAIR LOBBY	F301	4	406	5	0.06	400	44.66	20.3	0.11	775	44.66
271	LOUNGE	441	37	374	7.5	0.18	1100	347.82	280.5	0.32	775	347.82
272	OFFICE	440	1	150	5	0.06	400	14.00	5	0.04	775	14
274	OFFICE	438	1	150	5	0.06	400	14.00	5	0.04	775	14
275	OFFICE	436	1	150	5	0.06	400	14.00	5	0.04	775	14
279	OFFICE	434	1	150	5	0.06	400	14.00	5	0.04	775	14
286	OFFICE	433	1	150	5	0.06	400	14.00	5	0.04	775	14
288	GRR	432	12	235	5	0.06	800	72.85	58.75	0.09	775	72.85
289	OFFICE	431	1	150	5	0.06	400	14.00	5	0.04	775	14
290	OFFICE	430	1	150	5	0.06	400	14.00	5	0.04	775	14
302	GRR	428	12	235	5	0.06	800	72.85	58.75	0.09	775	72.85
303	OFFICE	426	1	150	5	0.06	400	14.00	5	0.04	775	14
304	GRR	424	12	235	5	0.06	800	72.85	58.75	0.09	775	72.85
305	OFFICE	422	1	150	5	0.06	400	14.00	5	0.04	775	14
318	THEORIST WORK AREA	401C	10	390	5	0.06	800	72.15	48.75	0.09	775	72.15
319	THEORIST WORK AREA	401B	10	380	5	0.06	1000	70.30	47.5	0.07	775	70.3
320	GRR	401E	10	202	5	0.06	250	62.62	50.5	0.25	775	62.62
321	COMP	401D	2	90	5	0.06	300	16.65	11.25	0.06	775	16.65
322	THEORIST SUITE	401	N/A	204	N/A	0.06	200	12.24	0	0.06	775	12.24
323	OFFICE	401A	1	262	5	0.06	375	20.72	5	0.06	775	20.72
326	OFFICE	402	1	168	5	0.06	275	15.08	5	0.05	775	15.08
327	OFFICE	404	1	138	5	0.06	225	13.28	5	0.06	775	13.28
328	OFFICE	406	1	138	5	0.06	225	13.28	5	0.06	775	13.28
329	OFFICE	407	1	138	5	0.06	225	13.28	5	0.06	775	13.28
339	OFFICE	412	1	138	5	0.06	225	13.28	5	0.06	775	13.28
340	OFFICE	413	1	138	5	0.06	225	13.28	5	0.06	775	13.28
341	OFFICE	414	1	138	5	0.06	225	13.28	5	0.06	775	13.28
342	OFFICE	416	1	138	5	0.06	225	13.28	5	0.06	775	13.28
343	OFFICE	417	1	138	5	0.06	225	13.28	5	0.06	775	13.28
344	LOUNGE	418	32	318	7.5	0.18	675	295.74	238.5	0.44	775	295.74
345	CORR	Q403	N/A	948	N/A	0.06	1000	56.88	0	0.06	775	56.88
346	CORR	Q401	N/A	252	N/A	0.06	1600	15.12	0	0.01	775	15.12
347	CORR	Q402	N/A	740	N/A	0.06	650	44.40	0	0.07	775	44.4
348	STAIR LOBBY	F401	4	406	5	0.06	400	44.66	20.3	0.11	775	44.66
351	LOUNGE	539	17	174	7.5	0.18	800	161.82	130.5	0.20	775	161.82
352	OFFICE	537	1	150	5	0.06	400	14.00	5	0.04	775	14
353	OFFICE	535	1	150	5	0.06	400	14.00	5	0.04	775	14
354	OFFICE	534	1	150	5	0.06	400	14.00	5	0.04	775	14
355	OFFICE	533	1	150	5	0.06	400	14.00	5	0.04	775	14
356	OFFICE	531	1	150	5	0.06	400	14.00	5	0.04	775	14
357	GRR	529	12	235	5	0.06	800	72.85	58.75	0.09	775	72.85
374	OFFICE	528	1	150	5	0.06	400	14.00	5	0.04	775	14
375	OFFICE	526	1	150	5	0.06	400	14.00	5	0.04	775	14
376	GRR	525	12	235	5	0.06	800	72.85	58.75	0.09	775	72.85
378	GRR	521	12	235	5	0.06	400	72.85	58.75	0.18	775	72.85



379	OFFICE	520	1	150	5	0.06	400	14.00	5	0.04	775	14	
395	CONFERENCE	501	16	320	5	0.06	450	99.20	80	0.22	775	99.2	
396	DEPT SEC	502	1	150	5	0.06	225	14.00	5	0.06	775	14	
398	GRR	504	11	228	10	0.18	450	155.04	114	0.34	775	155.04	
400	OFFICE	506	1	150	5	0.06	225	14.00	5	0.06	775	14	
403	OFFICE	509	1	150	5	0.06	225	14.00	5	0.06	775	14	
405	OFFICE	511	1	150	5	0.06	225	14.00	5	0.06	775	14	
406	OFFICE	512	1	150	5	0.06	225	14.00	5	0.06	775	14	
407	OFFICE	514	1	150	5	0.06	225	14.00	5	0.06	775	14	
409	GRR	516	11	228	5	0.06	450	70.68	57	0.16	775	70.68	
411	LOUNGE	517	25	252	7.5	0.18	450	234.36	189	0.52	775	234.36	
							72000						7421

$X_s$	0.1031	$E_v$	0.5
$MAX Z_p$	0.52	$V_{OR}$	14842
$D$	1		

AHU-4

Air handler 2 is a variable air volume unit which feeds laboratory spaces. The unit contains particulate filters, preheat, reheat and cooling coils, supply and return fans. It is located in the mechanical penthouse of the building. The AHU supplies 72,000 CFM to the designated spaces. The supply is made up of 100% outdoor air. The design minimum outdoor airflow is 14,842 CFM to the spaces. This is equivalent to about 21% of the total CFM supplied. Since the unit uses 100% outdoor air, it well exceeds the requirements set by ASHRAE Addendum 'n'.



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## CONCLUSION

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From the previous section, all four air handling units comply with Addendum 'n' of ASHRAE Standard 62. All of the units far exceed the requirement. This is because the units supply air is composed of 100% outdoor air. In addition, the design requirement is made on very basic information. With more in depth information on equipment use and chemicals used, it would be possible to take a more accurate estimation of the required ventilation.



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## VENTILATION RATE VS INDOOR AIR QUALITY PROCEDURES

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According to ASHRAE, there are two methods of evaluating a ventilation system for a building. The Ventilation Rate Procedure (VRP) prescribes ventilation rate based on volume and occupancy of a space. While Indoor Air Quality Procedure (IAQP), prescribes proper ventilation by limiting measure contaminant concentrations.

The Ventilation Rate Procedure lists design air flow rates chosen according to the volume and occupancy of the space. The rates were developed by the US Environmental Protection Agency (EPA) based on Carbon Dioxide levels. This method is quicker, and if spaces meet the requirements prescribed the outdoor air should be sufficient to ventilate the space. Other benefits include that this method is comparably less expensive than other alternatives.

The Indoor Air Quality Procedure lists acceptable levels of contaminants for particular spaces. This method was also developed by the EPA. Using this method will lead to more accuracy due to its direct approach. However, because of this method's additional contamination level restrictions in the calculation and its monitoring of ventilation in spaces; IAQP is the more expensive than VRP.

In conclusion, the VRP approach is more cost effective and time efficient when calculating everyday spaces where the risk of occupant contaminant exposure is at a minimum. However, when dealing with areas of high risk contaminant exposure, or when levels of contamination need to be monitored, the IAQP method is best suited.





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