

**MECHANICAL SYSTEMS**  
**EXISTING CONDITIONS EVALUATION**



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

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## TABLE OF CONTENTS

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- Executive Summary.....2
- Design Objective & Requirements.....4
- Energy Source & Rates.....4
- Site Factors.....5
- Outdoor Design Conditions.....6
- Indoor Design Requirements.....6
- Demand Schedule.....15
- Design Ventilation Requirements.....16
  - AHU-1.....18
  - AHU-2.....20
  - AHU-3.....22
  - AHU-4.....26
- Design Heating & Cooling Loads.....27
- All Energy Use.....29
- Building Mechanical Equipment.....29
  - Fan Schedule.....29
  - Water Pump Schedule.....30
  - Condensate Pump Schedule.....31
  - Condensate Pump Schedule.....32
  - Expansion Tank Schedule.....32
  - AHU Schedule.....32
  - Centrifugal Chiller Schedule.....33
  - Cooling Tower Schedule.....34
  - Heat Exchanger Schedule.....34
  - Plate & Frame Heat Exchanger Schedule.....34
- Building Zones.....35
- Building Schematics.....41
- Building Mechanical Operation Description.....42
  - Steam.....42
  - Hot Water.....42
  - Chilled Water.....42
  - Condenser Water.....43
  - Air Flow.....43
- Critique of Systems.....44
- References.....45



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CHEMISTRY BUILDING  
TECHNICAL ASSIGNMENT #3



## EXECUTIVE SUMMARY

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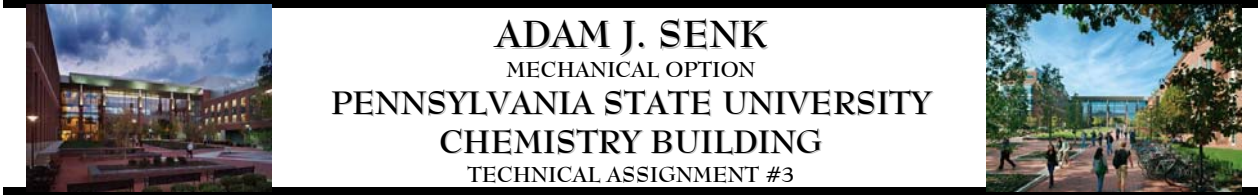
The following report is an evaluation of the mechanical systems of the Pennsylvania State University. In the report requirements and objectives for construction will be discussed first, leading into equipment. Equipment will be developed into two parts. The first part will display schedules, while the second part will display setup and usage using schematics and brief explanations. The report will conclude with a critique of the building and its systems.

Design objectives and requirements for this project range from site factors to use of an existing steam and chiller service setup. The first requirement that the designers had to deal with when designing the Penn State Chemistry Building was the area confines. The building was to be built on a plot of a land which was bounded on three sides by existing buildings while on the fourth was bounded by a street. In addition to these site confines, located within the site were two historical landmarks which had to be avoided from when Penn State was a farmer's college.

Because of this building being primarily a lab building several mechanical criteria had to be met. The first criteria that had to be met were the ventilation requirements supplied by ASHRAE 62.1. Also because the lab would contain volatile substances, the lab would have to be continuously exhausted. This resulted in the labs being at a negative pressure causing raised infiltration, which affected the demand schedule. Other criteria which affected the demand schedule where the hour of operation due to the building not having set occupational hours. These two factors resulted in flexibility being built into the schedule, and the down time being set at 20% for an off load requirement as suggested by the original design team to compensate for infiltration and the large amount of glazing. This greatly affected the building loads and energy use which can be noted from the tables in their corresponding sections.

In the remainder of the document, building schedules and operation of systems will be discussed in detail using schematics and brief explanations. The systems covered in these areas are: steam, hot water, chilled water, condenser water, and air flow.

The final section of this document is Critique of Systems. The Chemistry Building is fashionably integrated into the Penn State campus. Its design avoided disrupting historic sites and pedestrian traffic paths between buildings, while creating its own pedestrian path between itself and its sister building Life Science. In addition the building takes full advantage of the already existing systems of chilled water and steam in place for the campus. Only one small problem exists with the system keeping it from 100% satisfaction, a small problem with the buildings air handlers



bypass coil at part time load. The problem exists because the bypass coils do not allow the proper amounts of air to pass through at part time loads such as spring and fall. Because of this the building is either too hot or too cold during these seasons.

Overall, The Chemistry Building is a great addition to the Penn State Campus at University Park.



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## DESIGN OBJECTIVES & REQUIREMENTS

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Initial design requirements for the Pennsylvania State University's Chemistry Building are outlined in the following paragraphs, developing on the mechanical system of the building first and eventually moving on to the architectural characteristics.

The first objective the design team had to consider was meshing the new Chemistry Building with the existing campus mechanical infrastructure. Penn State uses chilled water for cooling in its new facilities. The chilled water is supplied from central plants located on campus. In addition, Penn State uses steam from the cogeneration plant on campus for the heating of its buildings. Other objectives include a ventilation plan to ventilate the laboratories of volatile substances.

Architectural requirements for the Chemistry Building are based primarily on its location. The first of these requirements was to design a building which fitted between Ritenour Medical Facilities and Fenske Lab, yet still keep it connected to its future sister building Life Science. Connecting it to its sister proved to be a challenging task because of Shortlidge Rd. This resulted in an enclosed atrium/bridge connecting the two buildings. An additional requirement surfaced after Pine Cottage was moved to make room for the new building. Spruce cottage an original building to the campus when it was a farmer's college now a historical landmark still laid in the way of the new Chemistry Building's progress. This resulted in the building shape being designed around the cottage, yielding a L-shaped building.

## ENERGY SOURCES & RATES

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The Pennsylvania State University at University Park has two energy sources implemented in its buildings on campus. The university uses chilled water from a central plant for cooling. The chillers consume electricity in order to cool the water. The central plant and Chemistry Building are both supplied with electricity by Allegheny Power at \$0.06/KWh. Heating for the building is supplied by using steam from a cogeneration electric plant. The steam is produced as a byproduct to the electricity; as a result there is no charge for its use.

Because of the existing system on campus at this time, flexibility for designers to choose an alternative system did not exist.





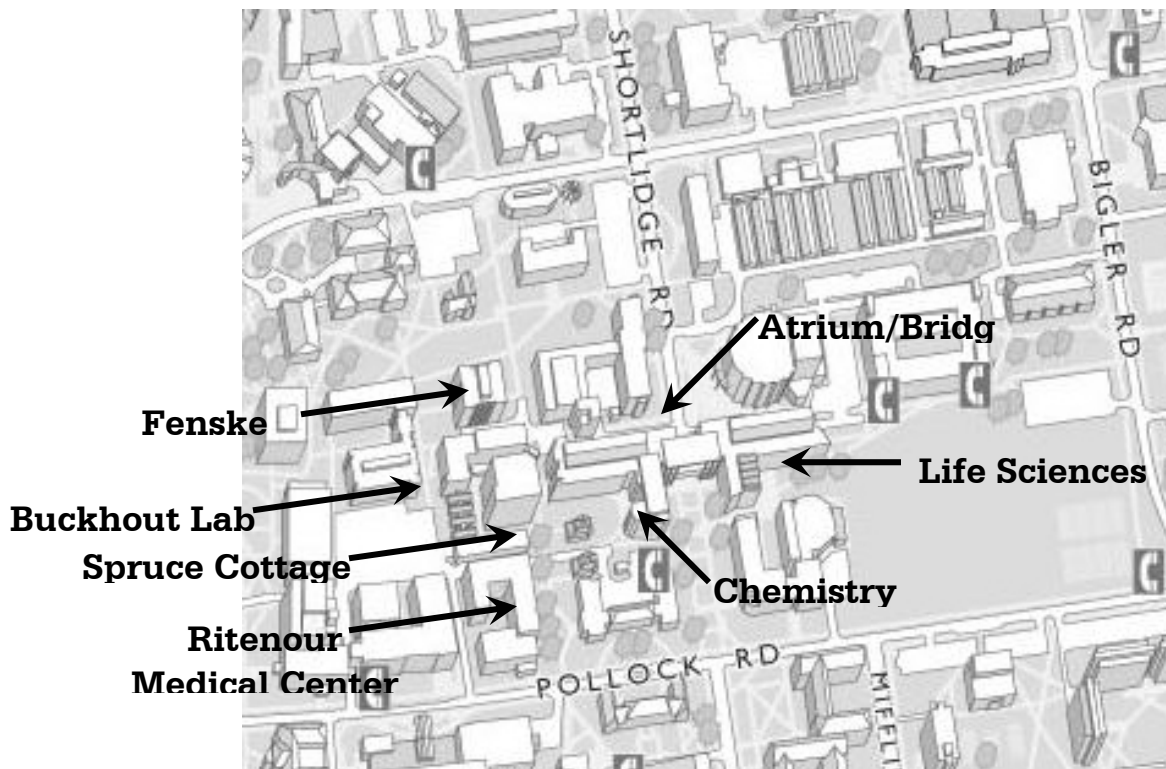
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## SITE FACTORS

The building site is surrounded on three sides by existing buildings; Fenske Lab, Ritenour Medical Center, Buckhout Lab; and bounded on the fourth side by Shortlidge Rd. In addition to these confines, within the site two historic cottages dating back to the university's conception were where the building was supposed to be located. Other physical problems also include connecting the Chemistry Building to its sister building Life Science which was to be built across the street.

To solve the problem of connecting the two buildings a bridge/atrium was incorporated into the design. Also, in order to save the historic buildings and meet the confines of the site an L-shaped building design was incorporated to avoid Spruce Cottage, while Pine Cottage was moved to a new location.





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## OUTDOOR DESIGN CONDITONS

Due to the lack information for weather data concerning the State College Area, the closest suitable replacement was Williamsport and then Harrisburgh.

City Name .....	<b>Williamsport</b>	
Location .....	<b>Pennsylvania</b>	
Latitude .....	<b>41.3</b>	Deg.
Longitude .....	<b>76.9</b>	Deg.
Elevation .....	<b>525.0</b>	ft
Summer Design Dry-Bulb .....	<b>90.0</b>	°F
Summer Coincident Wet-Bulb .....	<b>73.0</b>	°F
Summer Daily Range .....	<b>20.3</b>	°F
Winter Design Dry-Bulb .....	<b>2.0</b>	°F
Winter Design Wet-Bulb .....	<b>0.3</b>	°F
Atmospheric Clearness Number .....	<b>1.00</b>	
Average Ground Reflectance .....	<b>0.20</b>	
Soil Conductivity .....	<b>0.800</b>	BTU/(hr-ft-°F)
Local Time Zone (GMT +/- N hours) .....	<b>5.0</b>	hours
Consider Daylight Savings Time .....	<b>No</b>	
Simulation Weather Data .....	<b>Harrisburg (TMY)</b>	
Current Data is .....	<b>2001 ASHRAE Handbook</b>	
Design Cooling Months .....	<b>January to December</b>	

## INDOOR DESIGN REQUIREMENTS

These indoor design requirements are based on ASHRAE Standard 62.1.

<u>ZOE</u>	<u>SPACE</u>	<u>OCCUPANTS</u>	<u>SQ FT</u>	<u>OA REQ'T</u>		<u>AHU</u>	<u>CFM</u>
				<u>CFM/PERS</u>	<u>CFM/FT<sup>2</sup></u>		
<b>BASEMENT</b>							
1	SMALL INSTRUMENT LAB	023B	8	256	10	0.18	575
2	GRR	025	13	256	5	0.06	500
3	MEDIUM INSTRUMENT LAB	023A	29	952	10	0.18	1550
4	INSTRUMENT RM	023	5	177	10	0.18	600
5	OFFICE	026	2	154	5	0.06	150
6	OFFICE	024	2	154	5	0.06	150
7	OFFICE	022	2	120	5	0.06	125
8	OFFICE	021	2	120	5	0.06	125
9	OFFICE	020	2	120	5	0.06	125
10	OFFICE	023C	2	116	5	0.06	125
11	OFFICE	023E	1	102	5	0.06	125
12	OFFICE	023F	1	102	5	0.06	125
13	MEN'S LAVATORY	R020	N/A	362	N/A	N/A	400



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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

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





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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	ACADEMIC OFFICE	101	2	476	5	0.06	4	400
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



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**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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
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



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**PENNSYLVANIA STATE UNIVERSITY**  
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 TECHNICAL ASSIGNMENT #3



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
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



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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
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



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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
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





**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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
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



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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

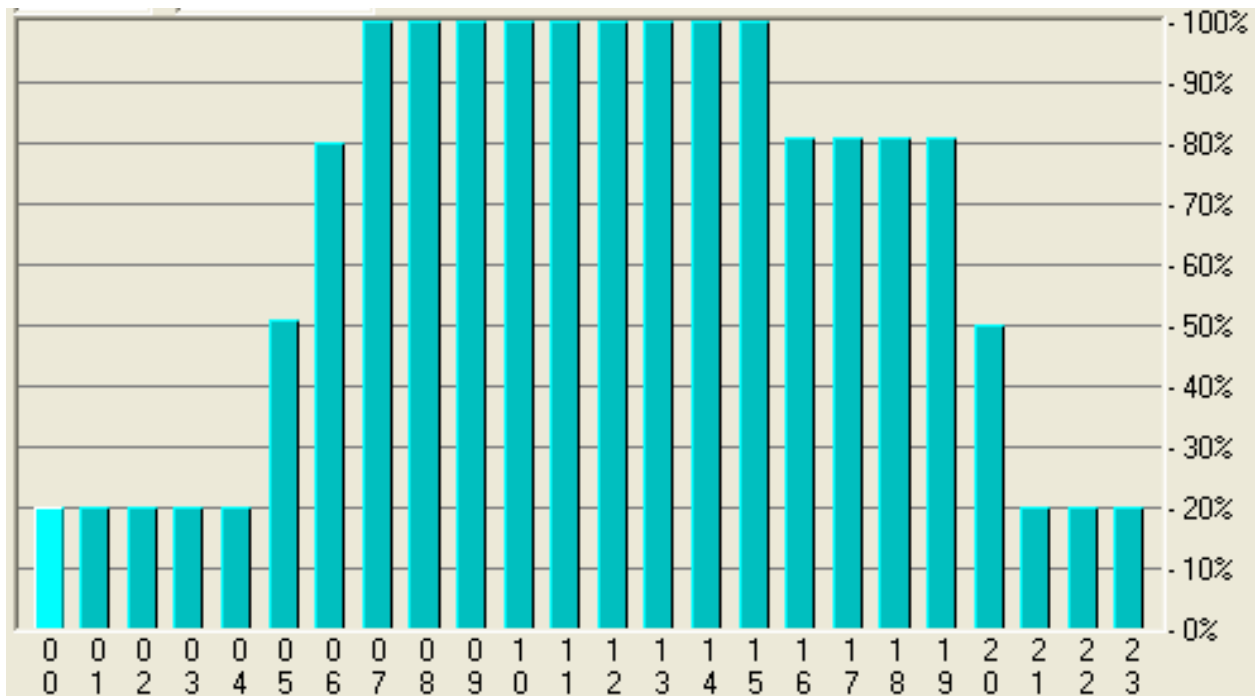


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MECHANICAL OPTION  
PENNSYLVANIA STATE UNIVERSITY  
CHEMISTRY BUILDING  
TECHNICAL ASSIGNMENT #3



## DEMAND SCHEDULE

The design loads for the Chemistry Building were calculated using the schedule below. Because the lab areas will be occupied mostly by graduate students, the hours of operation are long throughout the day and have partial occupation in the later evening hours. In addition, because the building is mostly science labs which need to be at a negative pressure, infiltration will be high as a result. This causes a partial load of 20 percent recommended by the original design team of the building. Also contributing to the partial load is the large amounts of glass which surround other parts of the building.





**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



## DESIGN VENTILATION REQUIREMENTS

ASHRAE 62.1 variables and formulas used in the calculation of the ventilation requirement.

ADDENDUM 'N' VARIABLES	
<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

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



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



Ventilation design calculation table.

ZONE	SPACE	$P_z$	$A_z$	$R_p$	$R_A$	$V_{PZ}$	$V_{OZ}$	$V_{PZM}$	$Z_p$	$P_s$	$V_{OU}$	
<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





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'.



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



<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
222	BIO CHEM	318B	4	665	10	0.12	1500	119.80	40	0.08	337	119.8



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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'.



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



ZONE	SPACE	P <sub>Z</sub>	A <sub>Z</sub>	R <sub>P</sub>	R <sub>A</sub>	V <sub>PZ</sub>	V <sub>OZ</sub>	V <sub>PZM</sub>	Z <sub>P</sub>	P <sub>S</sub>	V <sub>OU</sub>
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AHU-3												
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
334	MEDIUM INSTRUMENT LAB	411	13	504	10	0.18	1000	216.72	126	0.22	587	216.72



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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

$\underline{X}_s$	0.1408	$\underline{E}_v$	0.5
$\underline{MAX Z}_p$	0.68	$\underline{V}_{OT}$	20412
$\underline{D}$	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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**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



<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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AHU-4												
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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 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



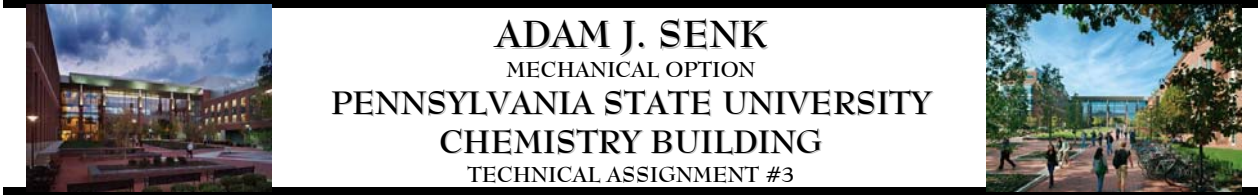
131	OFFICE	230	1	150	5	0.06	400	14.00	5	0.04	775	14
135	OFFICE	228	1	150	5	0.06	400	14.00	5	0.04	775	14
136	GRR	226	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
140	OFFICE	224	1	150	5	0.06	400	14.00	5	0.04	775	14
144	GRR	222	12	242	5	0.06	800	75.02	60.5	0.09	775	75.02
147	OFFICE	220	1	150	5	0.06	400	14.00	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



**ADAM J. SENK**  
 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3



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



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 MECHANICAL OPTION  
**PENNSYLVANIA STATE UNIVERSITY**  
**CHEMISTRY BUILDING**  
 TECHNICAL ASSIGNMENT #3

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

$\underline{X}_s$	0.1031	$\underline{E}_v$	0.5
$\underline{MAX Z}_p$	0.52	$\underline{V}_{OI}$	14842
$\underline{D}$	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 25% outdoor air, it well exceeds the requirements set by ASHRAE Addendum 'n'.



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 TECHNICAL ASSIGNMENT #3



**DESIGN HEATING & COOLING LOADS**

<b>Monthly Simulation Results for AHU-1</b>	
Project Name: Tech 2 Prepared by: Penn State	11/12/2005 02:35PM

**Air System Simulation Results (Table 1) :**

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Central Heating Coil Load (kBTU)	Supply Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	297230	676	52631	24976	19985	40666
February	229347	103	34019	22314	18145	36403
March	125774	9672	23772	24369	20228	39820
April	39822	106732	18065	24321	19372	39245
May	310	216469	1198	25163	19619	40243
June	0	520071	0	24640	19981	38822
July	0	632929	0	25915	19985	40666
August	0	599088	0	25248	20228	39820
September	119	305220	162	24663	19372	39245
October	31454	130500	7589	25267	19985	40666
November	102401	24974	28556	23525	19615	38399
December	214980	1123	44933	24977	19985	40666
<b>Total</b>	<b>1041437</b>	<b>2547556</b>	<b>210925</b>	<b>295379</b>	<b>236502</b>	<b>474658</b>

<b>Monthly Simulation Results for AHU-2</b>	
Project Name: Tech 2 Prepared by: Penn State	11/12/2005 12:56PM

**Air System Simulation Results (Table 1) :**

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Central Heating Coil Load (kBTU)	Supply Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	365265	6565	27377	28656	23476	68317
February	281843	5229	24437	25624	21314	61156
March	154563	24556	16880	28089	23761	66896
April	48937	152880	9123	28053	22755	65930
May	381	307097	292	29113	23045	67606
June	0	667092	0	28396	23471	65219
July	0	801544	0	29772	23476	68317
August	0	765917	0	29063	23761	66895
September	146	414697	131	28502	22755	65930
October	38654	197149	5292	29223	23476	68317
November	125840	44291	17069	27136	23041	64508
December	264188	9120	22952	28721	23476	68317
<b>Total</b>	<b>1279817</b>	<b>3396135</b>	<b>123553</b>	<b>340350</b>	<b>277806</b>	<b>797409</b>





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 CHEMISTRY BUILDING  
 TECHNICAL ASSIGNMENT #3



**Monthly Simulation Results for AHU-3**

Project Name: Tech 2 11/12/2005  
 Prepared by: Penn State 12:52PM

**Air System Simulation Results (Table 1) :**

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Central Heating Coil Load (kBTU)	Supply Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	673053	75395	102787	21276	18543	158396
February	519338	70279	80592	19082	16836	141796
March	284805	109956	51824	21045	18769	155111
April	90173	289554	31669	20968	17974	152863
May	702	491203	4614	21834	18203	156745
June	0	1085155	74	21236	18539	151229
July	0	1311090	0	22259	18543	158396
August	0	1237136	0	21785	18769	155111
September	270	659239	1106	21344	17974	152863
October	71226	339394	21418	21881	18543	158396
November	231878	134386	53407	20309	18199	149578
December	486806	82224	89649	21371	18543	158396
<b>Total</b>	<b>2358252</b>	<b>5885009</b>	<b>437140</b>	<b>254391</b>	<b>219435</b>	<b>1848881</b>

**Monthly Simulation Results for AHU-4**

Project Name: Tech 2 11/12/2005  
 Prepared by: Penn State 01:03PM

**Air System Simulation Results (Table 1) :**

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Terminal Heating Coil Load (kBTU)	Supply Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	10828	15377	33850	4543	16681	29040
February	13312	13595	12769	4245	15145	25996
March	19874	23898	128	5854	16882	28436
April	10359	147649	0	7930	16169	28025
May	204	279637	0	10099	16376	28738
June	0	683812	0	11721	16675	27723
July	0	856384	0	13252	16681	29040
August	0	768278	0	11898	16882	28436
September	76	385269	0	10263	16169	28025
October	5874	177945	0	8529	16681	29040
November	14691	35602	272	5415	16370	27421
December	8023	16968	10054	4648	16681	29040
<b>Total</b>	<b>83242</b>	<b>3404415</b>	<b>57072</b>	<b>98396</b>	<b>197393</b>	<b>338958</b>



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 TECHNICAL ASSIGNMENT #3



**ANNUAL ENERGY USE**

BUILDING ELECTRIC USE			
SOURCE	KW/hr	RATE \$(/KW/hr)	OPERATION COST
AHU	5581031.78	\$0.06	\$334,861.91
LIGHTING	988486	\$0.06	\$59,309.16
EQUIPMENT	681136	\$0.06	\$40,868.16
COND. PUMP	525	\$0.06	\$31.50
SUPPLY FAN	3459906	\$0.06	\$207,594.36
<b>TOTAL:</b>	<b>10711085</b>	<b>\$0.06</b>	<b>\$642,665.09</b>

**BUILDING MECHANICAL EQUIPMENT**

FAN SCHEDULE											
UNIT	LOCATION	SERVICE	CFM	S.P. (IN.H2O)	RPM	WHEEL DIA. (IN.)	MOTOR DATA @ 60HZ				FAN TYPE
							MBHP	MHP	VOLTS	PHASE	
EX-1	Penthouse	Lab EXH	90,000	4.5	549	73	93.1	125	480	3	SWSI
EX-2	Penthouse	Lab EXH	90,000	4.5	549	73	93.1	125	480	3	SWSI
EX-3	Penthouse	Lab EXH	100,000	4.5	563	73	101	125	480	3	SWSI
EX-4	Penthouse	Lab EXH	100,000	4.5	563	73	101	125	480	3	SWSI
EX-5	Penthouse	Lab EXH	72,500	4.5	1,770	48	66	75	480	3	AXIAL
EX-6	Penthouse	Lab EXH	72,500	4.5	1,770	48	66	75	480	3	AXIAL
EX-7	Penthouse	Load EXH	2,000	1.5	1,940	15	0.92	1.5	480	3	SWSI
EX-8A	Penthouse	R.I. EXH	1,850	6	2,420	13.5	2.93	5	480	3	SWSI
EX-8B	Penthouse	R.I. EXH	1,850	6	2,420	13.5	2.93	5	480	3	SWSI
EX-9A	Basement	MER EXH	5,000	0.5	1,300	24	x	0.75	480	3	PROP
EX-9B	Basement	MER EXH	5,000	0.5	1,300	24	x	0.75	480	3	PROP



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EX-9C	Basement	MER EXH	5,000	0.5	1,300	24	x	0.75	480	3	PROP
EX-9D	Basement	MER EXH	5,000	0.5	1,300	24	x	0.75	480	3	PROP
EX-10A	Basement	ELEC EXH	7,500	0.5	968	30	x	1	480	3	PROP
EX-10B	Basement	ELEC EXH	7,500	0.5	968	30	x	1	480	3	PROP
EX-11	Penthouse	Penthouse Vent	20,000	1.5	1,770	30	10	15	480	3	PROP
EX-12	Penthouse	Toilet EXH	4,625	2	1,610	18	2.53	3	480	3	PROP
EX-13	Penthouse	Atrium EXH	15,000	2	1,770	30	8	10	480	3	PROP
RF-1	Penthouse	AHU-4	36,000	4	1,770	42	41	50	480	3	AXIAL
RF-2	Penthouse	AHU-5	36,000	4	1,770	42	41	50	480	3	AXIAL
SF-1A	Basement	ELEC EXH	7,500	1.5	1,770	24	3.4	5	480	3	IN-LINE
SF-1B	Basement	ELEC EXH	7,500	1.5	1,770	24	3.4	5	480	3	IN-LINE
SF-2	Basement	EMER ELEC	1,000	0.5	1,160	16	x	0.25	120	1	PROP

WATER PUMP SCHEDULE											
UNIT	LOCATION	SERVICE	TYPE	GPM	TOTAL HEAD (FT H2O)	MAX. NPSH	MOTOR DATA @ 60HZ				
							BHP	MHP	RPM	VOLTS	PHASE
CMP-1	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-2	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-3	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-4	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-5	Basement	Cond. Water	End Suction	360	70	6	8.5	10	1,750	480	3
CMP-6	Basement	Cond. Water	End Suction	360	70	6	8.5	10	1,750	480	3
HMP-1	Penthouse	Hot Water	End Suction	570	50	7	8.5	10	1,750	480	3



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HMP-2	Penthouse	Hot Water	End Suction	570	50	7	8.5	10	1,750	480	3
HMP-3	Penthouse	Zone Façade (N)	In-Line	32	35	4	0.75	1	1,750	480	3
HMP-4	Penthouse	Zone Façade	In-Line	44	35	4	0.75	1	1,750	480	3
HMP-5	Penthouse	Zone Façade (S)	In-Line	44	35	4	0.75	1	1,750	480	3
HMP-6	Penthouse	Zone Façade (E)	In-Line	20	35	4	0.5	0.75	1,750	480	3
HMP-7	Penthouse	Zone Façade	In-Line	25	35	4	0.5	0.75	1,750	480	3
HMP-8	Penthouse	Zone Façade (W)	In-Line	10	35	4	0.5	0.75	1,750	480	3
CHP-1	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-2	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-3	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-4	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
PCHP-1	Basement	Proc. Chilled	End Suction	360	60	6	6.5	10	1,750	480	3
PCHP-2	Basement	Proc. Chilled	End Suction	360	60	6	6.5	10	1,750	480	3

CONDENSATE PUMP SCHEDULE							
UNIT	LOCATION	#s/HR	GPM	STEAM PSI	SUCTION TEMP	BACK-PRESS PSI	# OF PUMPS
CP-1	BASEMENT	30000	350	90	212	60	1



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CONDENSATE PUMP SCHEDULE											
UNIT	LOCATION	MIN. REC. CAPACITY (GAL)	MIN. VENT SIZE (INCH)	GPM	SUCTION TEMP.	DISCH. PRESS. (PSIG)	# PUMPS	MOTOR DATA @ 60HZ			
								MHP EA	RPM	VOLTS	PHASE
CP-2	BASEMENT	52	2.5	45	212	15	2	1.5	3,500	480	3

EXPANSION TANK SCHEDULE							
UNIT	LOCATION	SYSTEM SERVED	INIT. CHARGE (PSIG)	TANK CAPACITY (GAL)	STYLE	TANK LENGTH (IN) x DIA. (IN)	RELIEF VALVE SETTING (PSIG)
TK-1	Penthouse	Hot Water	50	370	VERT.	100x36	90
TK-2	Basement	Chilled Water	50	211	VERT.	83x30	90
TK-3	Basement	Chilled Water	50	150	VERT.	65x30	90

AHU									
AHU	LOCATION	CFM	OA	SUPPLY FAN					
				Quantity	FAN Type	Min. SP	Max. BHP	Min. BHP	RPM
AHU-1	Penthouse	90,000	90,000	2	VFD	8	85	100	1,346
AHU-2	Penthouse	100,000	100,000	2	VFD	8	97	125	1,406
AHU-3	Penthouse	72,500	72,500	2	VFD	8	68	100	1,489
AHU-4	Penthouse	72,000	18,000	2	VFD	8	68	100	1,489





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AHU (CONTINUED)											
PREHEAT COIL				COOLING COIL							
AIR SIDE			STEAM	AIR SIDE				WATER SIDE			
Max. Face Velocity (FPM)	EDB (°F)	LDB (°F)	Flow (lbs/hr)	EDB (°F)	EWB (°F)	LDB (°F)	LWB (°F)	Fluid	Flow GPM	EWT (°F)	LWT (°F)
800	0	55	5,569	90	74	47	46.9	Water	1,008	40	56
800	0	55	6,188	90	74	47	46.9	Water	1,062	40	56
800	0	55	4,486	90	74	47	46.9	Water	765	40	56
800	45	55	810	79	66	47	46.9	Water	491	40	56

CENTRIFUGAL CHILLER SCHEDULE										
		ELEC. DATA		EVAPORATOR						
UNIT	# TONS	VOLTS	PHASE	EWT (°F)	LWT (°F)	GPM	FLUID	# PASSES	FOULING FACTOR	ΔP (FT H2O)
CH-1	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34
CH-2	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34
CH-3	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34

CENTRIFUGAL CHILLER SCHEDULE (CONTINUED)								
CONDENSOR						COMPRESSOR DATA		
EWT (°F)	LWT (°F)	GPM	# PASSES	FOULING FACTOR	ΔP (FT H2O)	RLA	KW RATING	KW/TON MAX
83	93	3,822	2	0.001	24	130	833	0.617
83	93	3,822	2	0.001	24	130	833	0.617
83	93	3,822	2	0.001	24	130	833	0.617



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COOLING TOWER SCHEDULE												
UNIT	TONS	EWT (°F)	LWT (°F)	EAT (°F)	GPM	QUANTITY FANS	MOTOR DATA @ 60HZ					
							MHP	RPM	SPEEDS	REVERS.	VOLTS	PHASE
CT-1	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-2	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-3	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-4	1,015	93	83	75	2,867	1	75	X	2	Y	480	3

HEAT EXCHANGER (STEAM-WATER) SCHEDULE														
UNIT	LOCATION	TUBE LENGTH	SHELL DIAMETER	# OF PASSES	WATER SIDE (TUBE)							STEAM SIDE (SHELL)		
					EWT (°F)	LWT (°F)	GPM	ΔP (FT H2O)	MIN. MBH	FOULING FACTOR	PRESS. RATING	OPER. PRESS	#'s PER HOUR	PRESS. RATING
HE-1	Penthouse	48	18	4	150	190	570	2	9,000	0.001	150	5	11,500	150
HE-2	Penthouse	48	18	4	150	190	570	2	9,000	0.001	150	5	11,500	150

PLATE & FRAME HEAT EXCHANGER SCHEDULE																	
UNIT	LOCATION	MIN. # PLATES	SIDE A							SIDE B							
			EWT (°F)	LWT (°F)	GPM	ΔP (PSI)	FLUID	FOULING FACTOR	PRESS. RATING	EWT (°F)	LWT (°F)	GPM	ΔP (PSI)	FLUID	FOULING FACTOR	PRESS. RATING	
HE-3	Basement	53	40	56	225	5	Water	0.00025	130	60	50	360	10	Water	0.00025	130	
HE-4	Basement	101	47	57	360	5	Water	0.00025	130	60	50	360	10	Water	0.00025	130	



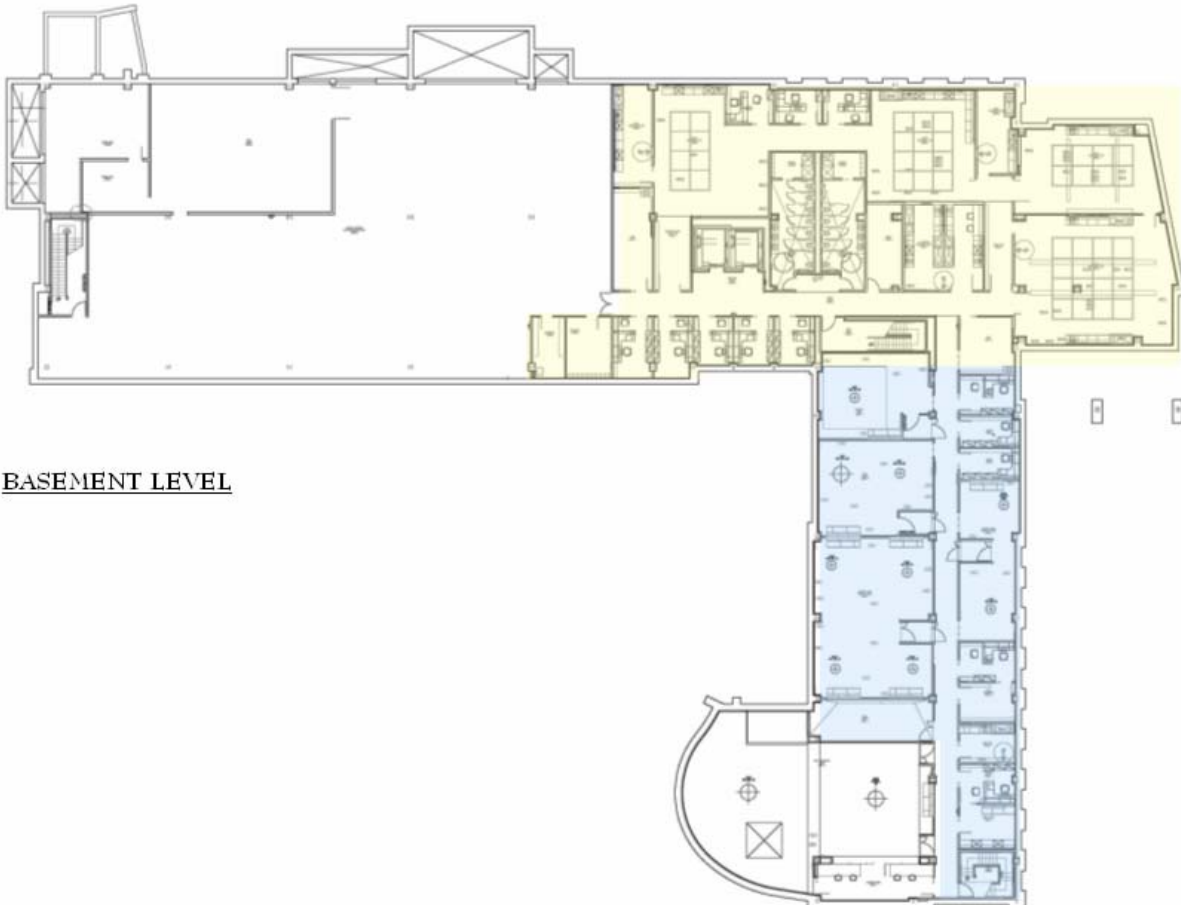
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## BUILDING ZONES

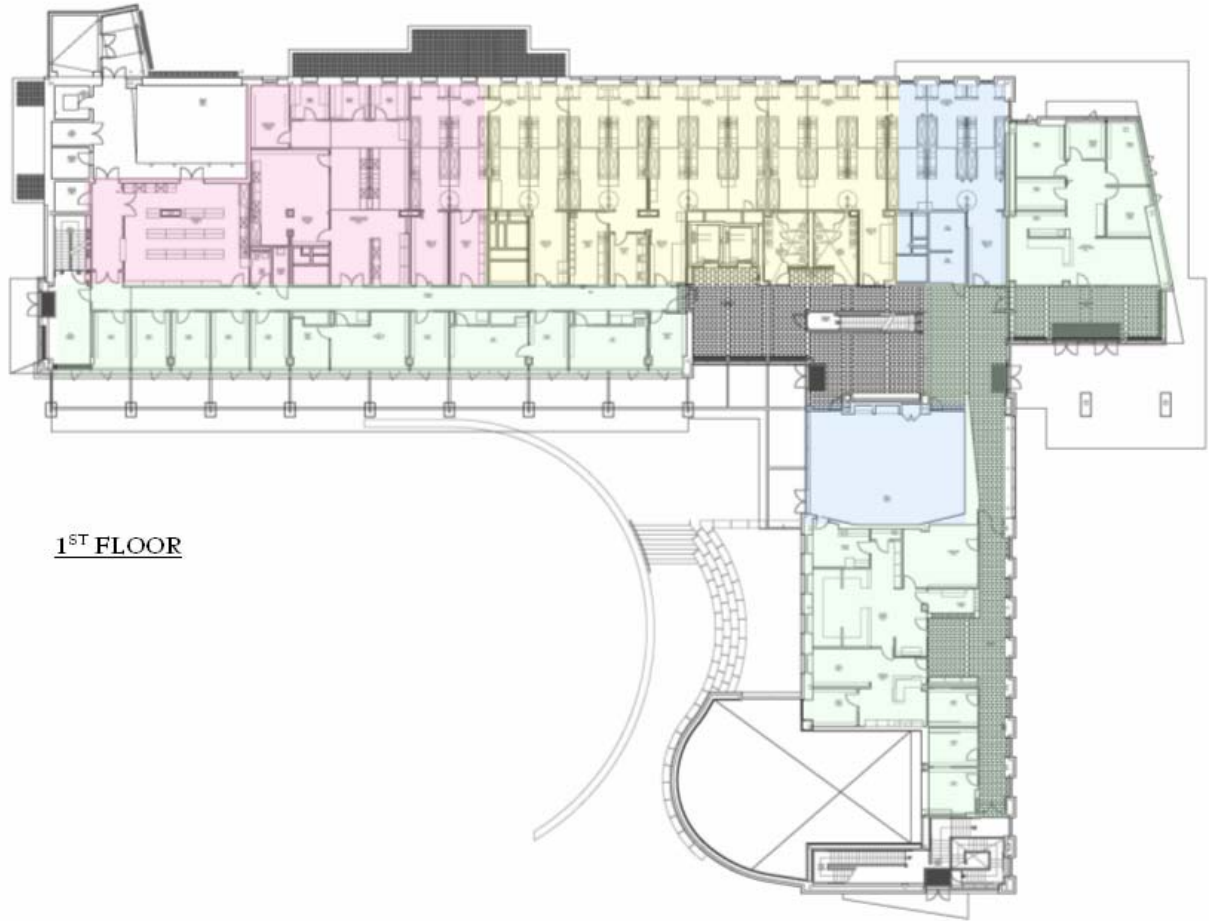
The building is split into four major zones per floor, except for the basement which is split into two major zones. Each of the zones is fed by one air handler. Laboratories are fed by air handlers 1-3, while offices are fed by air handler 4. All of the laboratories are on a constant air volume system with an outdoor air making up 100% of the supply air. Offices are fed by a variable air volume system with outdoor making up 25% 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
AHU-1	90000	90000	CARRIER	CV	PENTHOUSE	Pink
AHU-2	100000	100000	CARRIER	CV	PENTHOUSE	Yellow
AHU-3	72500	72500	CARRIER	CV	PENTHOUSE	Blue
AHU-4	72000	72000	CARRIER	VV	PENTHOUSE	Green





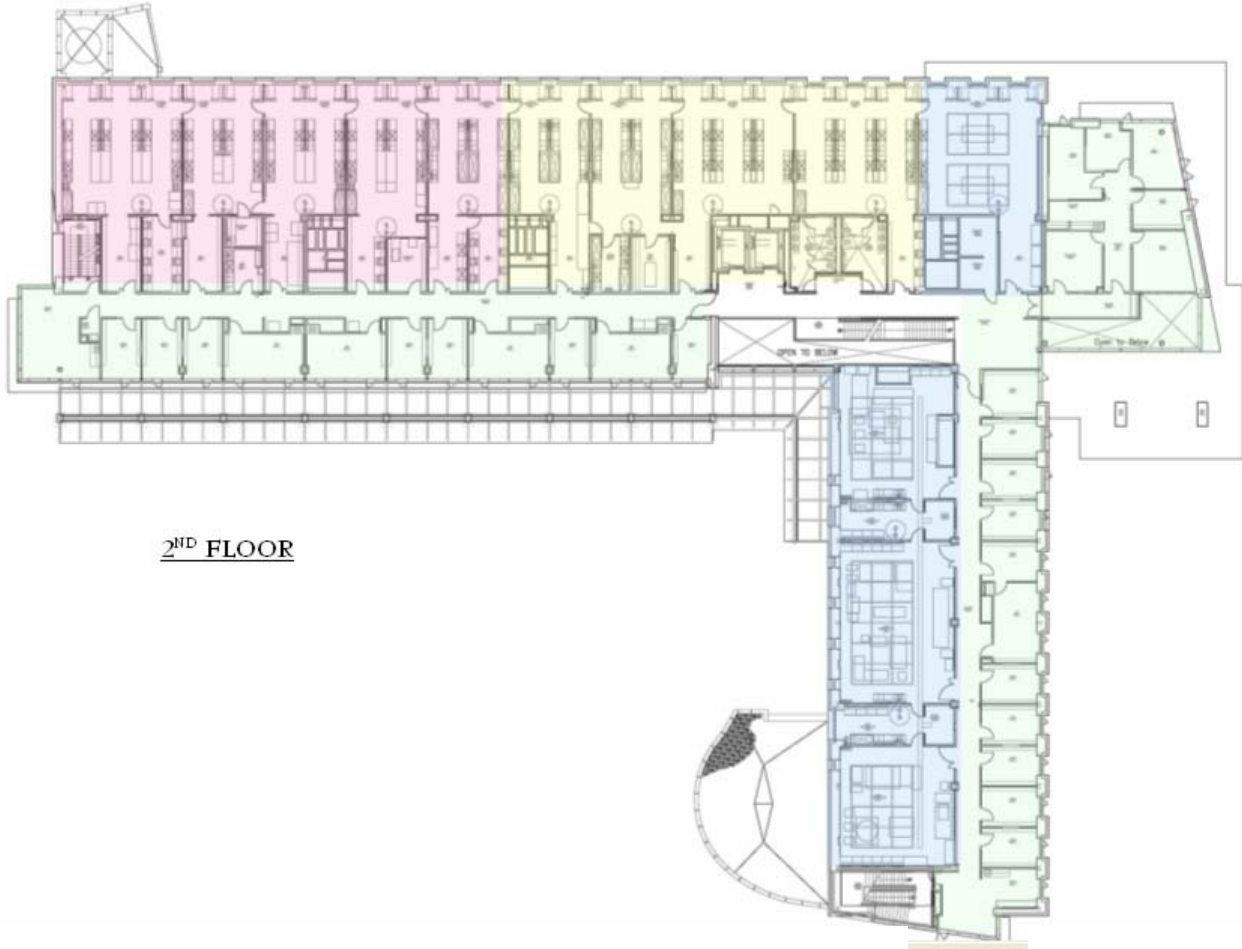
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1<sup>ST</sup> FLOOR



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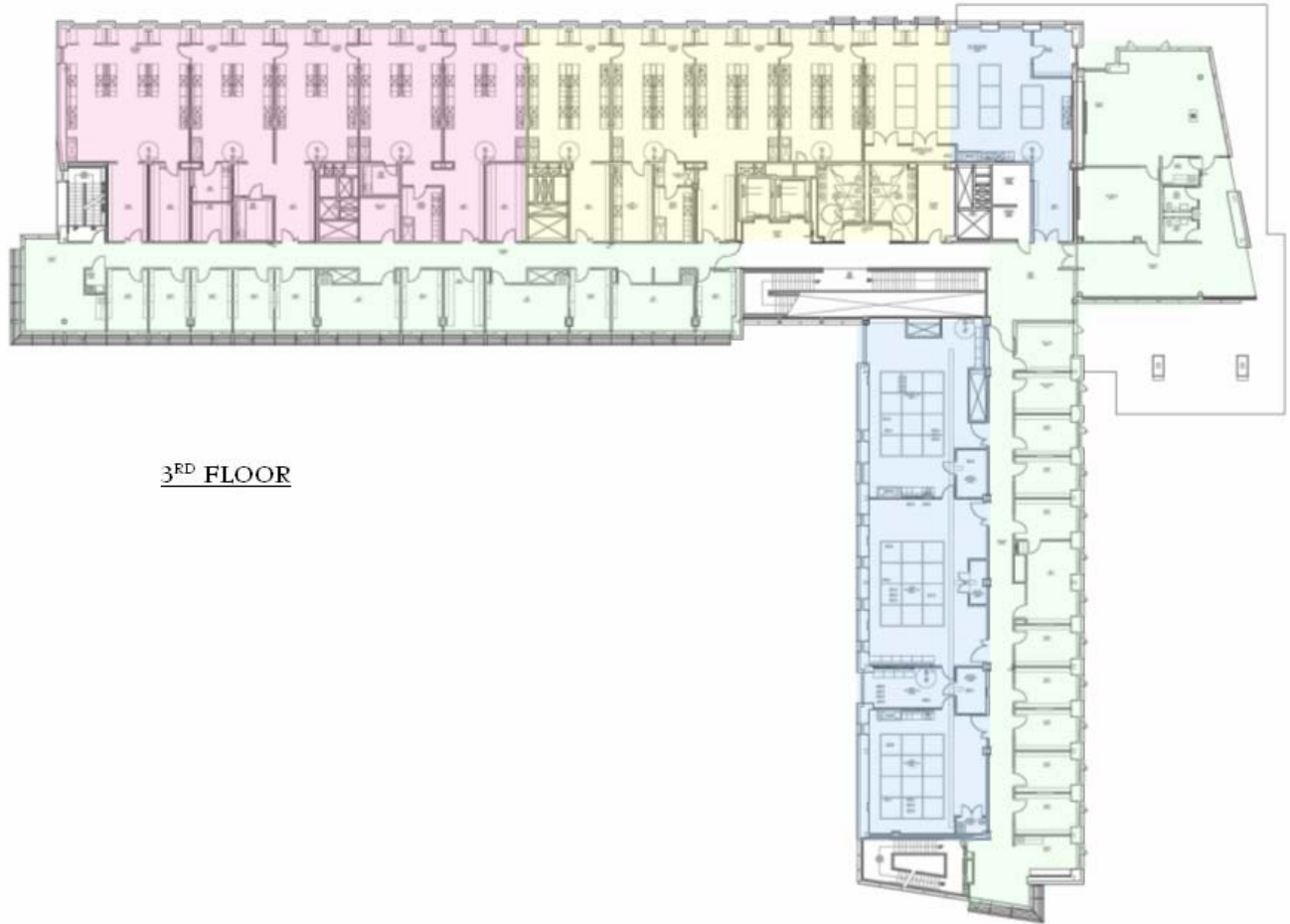


2<sup>ND</sup> FLOOR





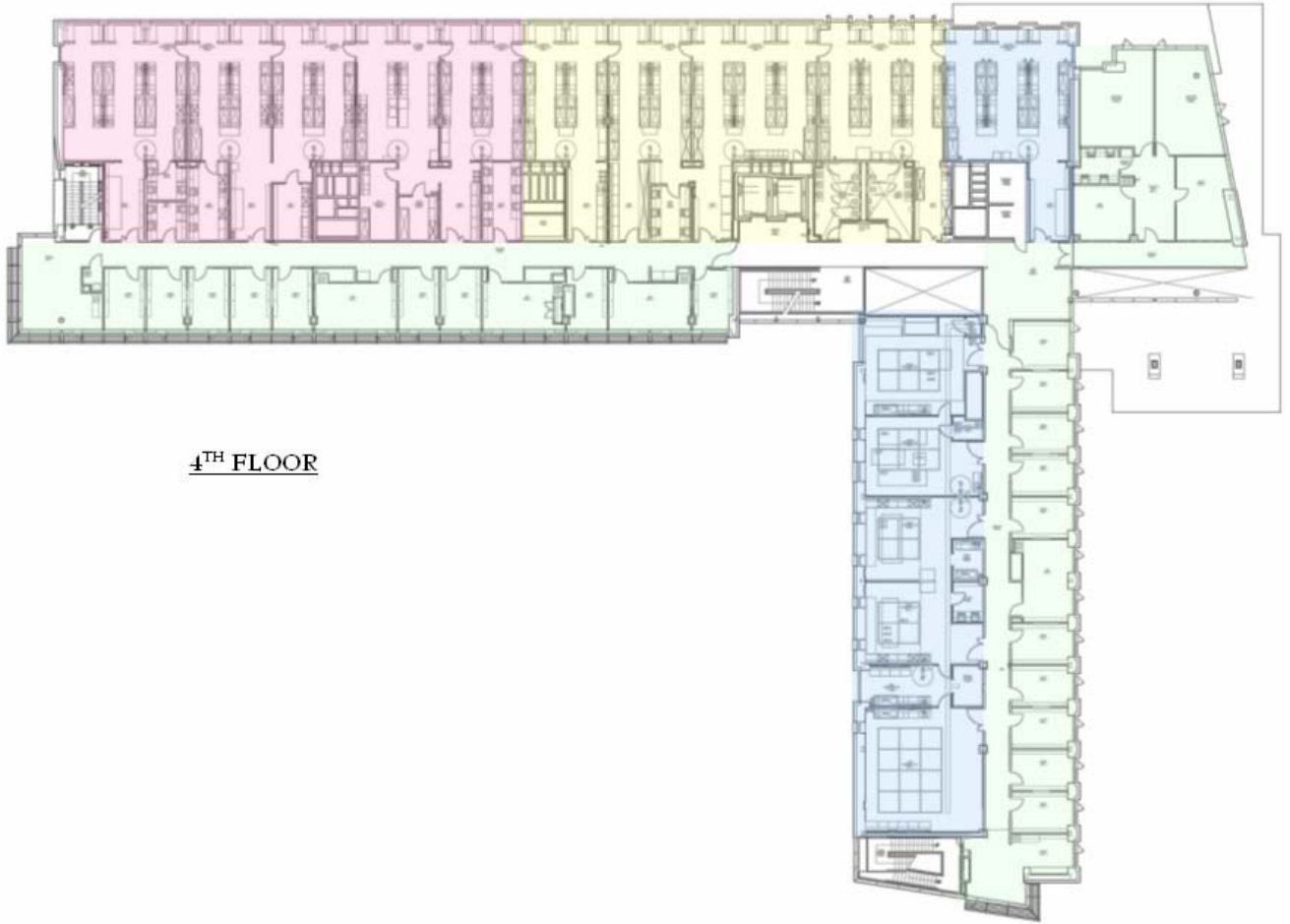
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3<sup>RD</sup> FLOOR



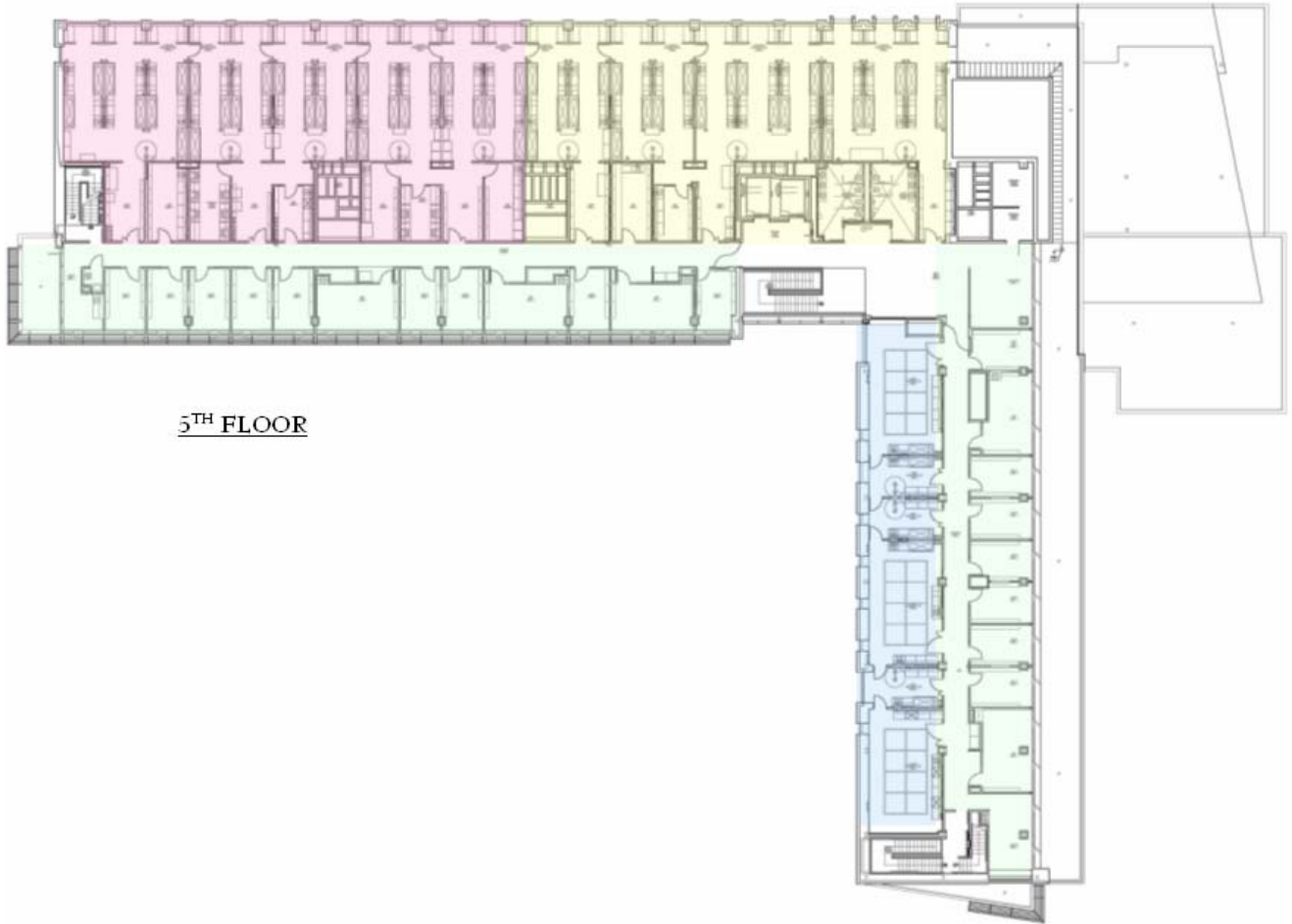
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4<sup>TH</sup> FLOOR



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5<sup>TH</sup> FLOOR



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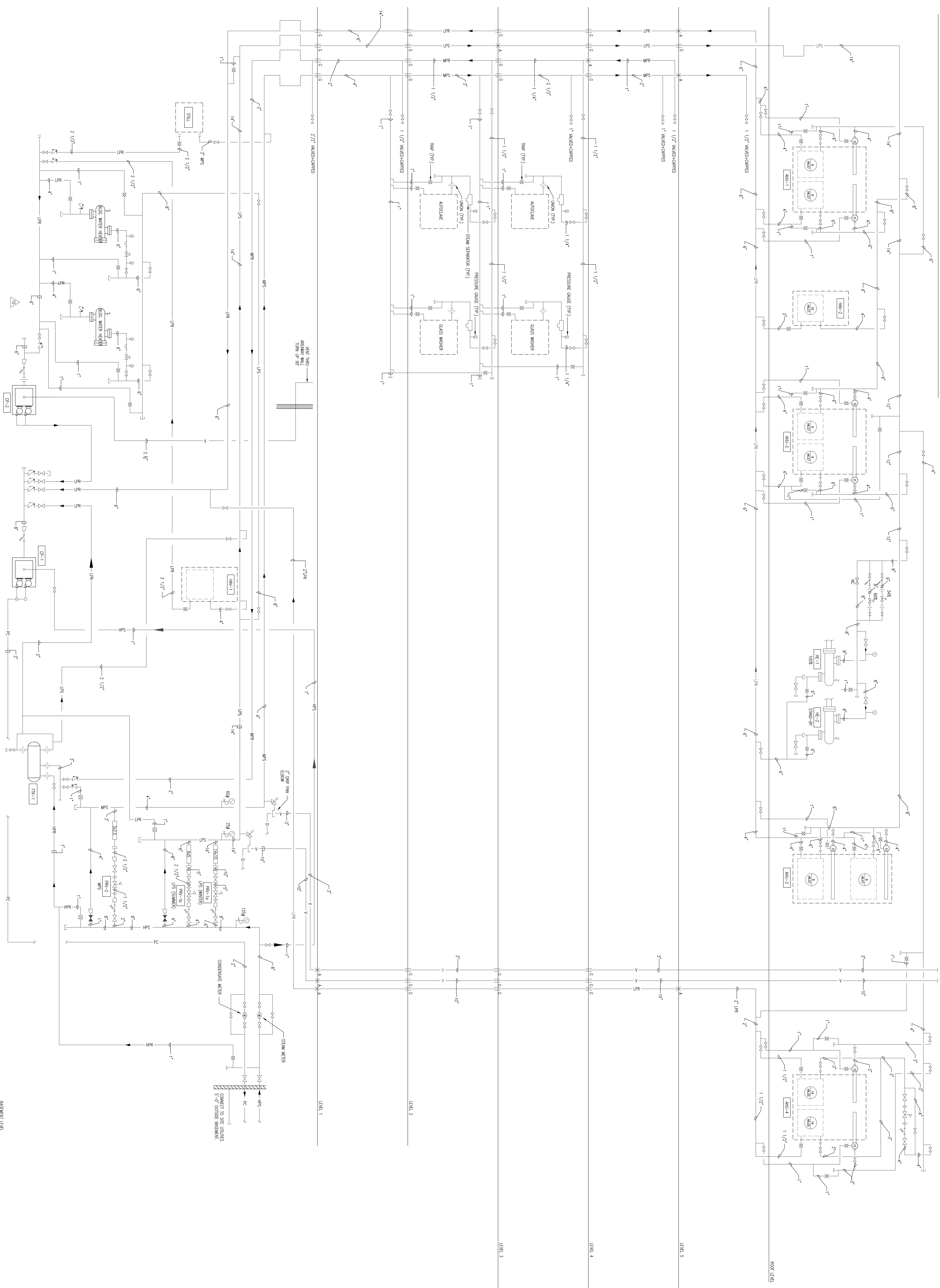


## **BUILDING MECHANICAL SCHEMATICS**

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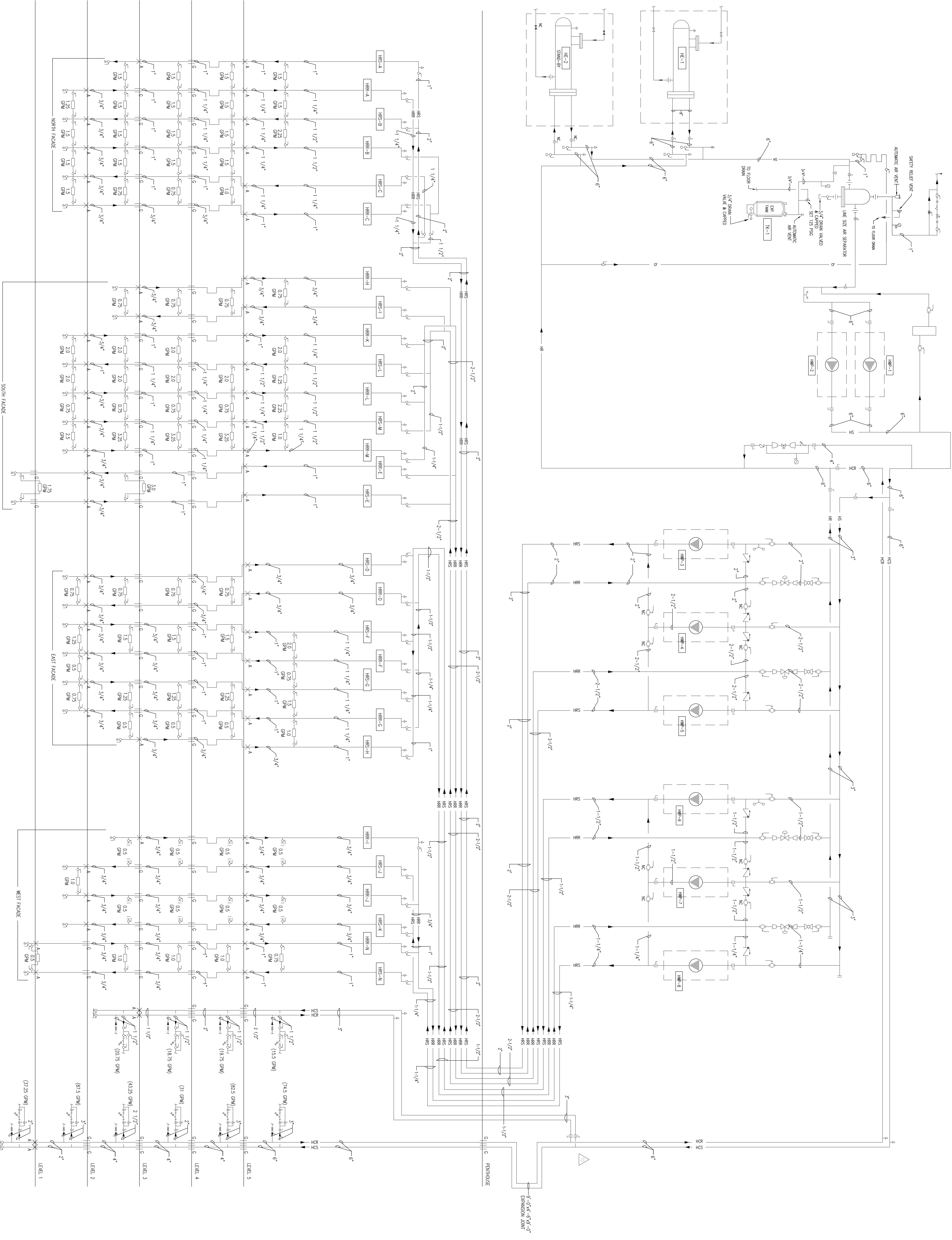
See Following Pages

# STEAM SCHEMATIC

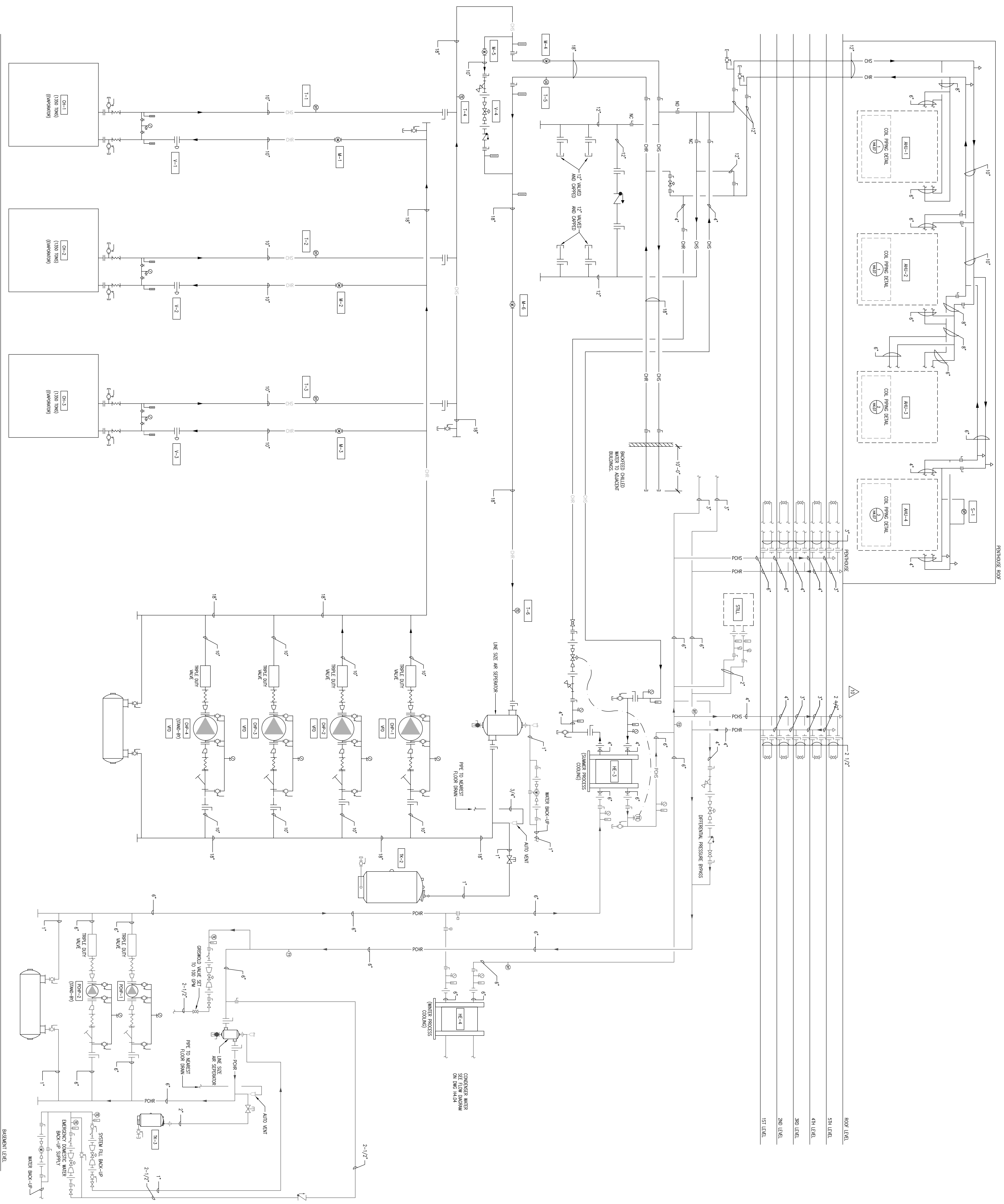




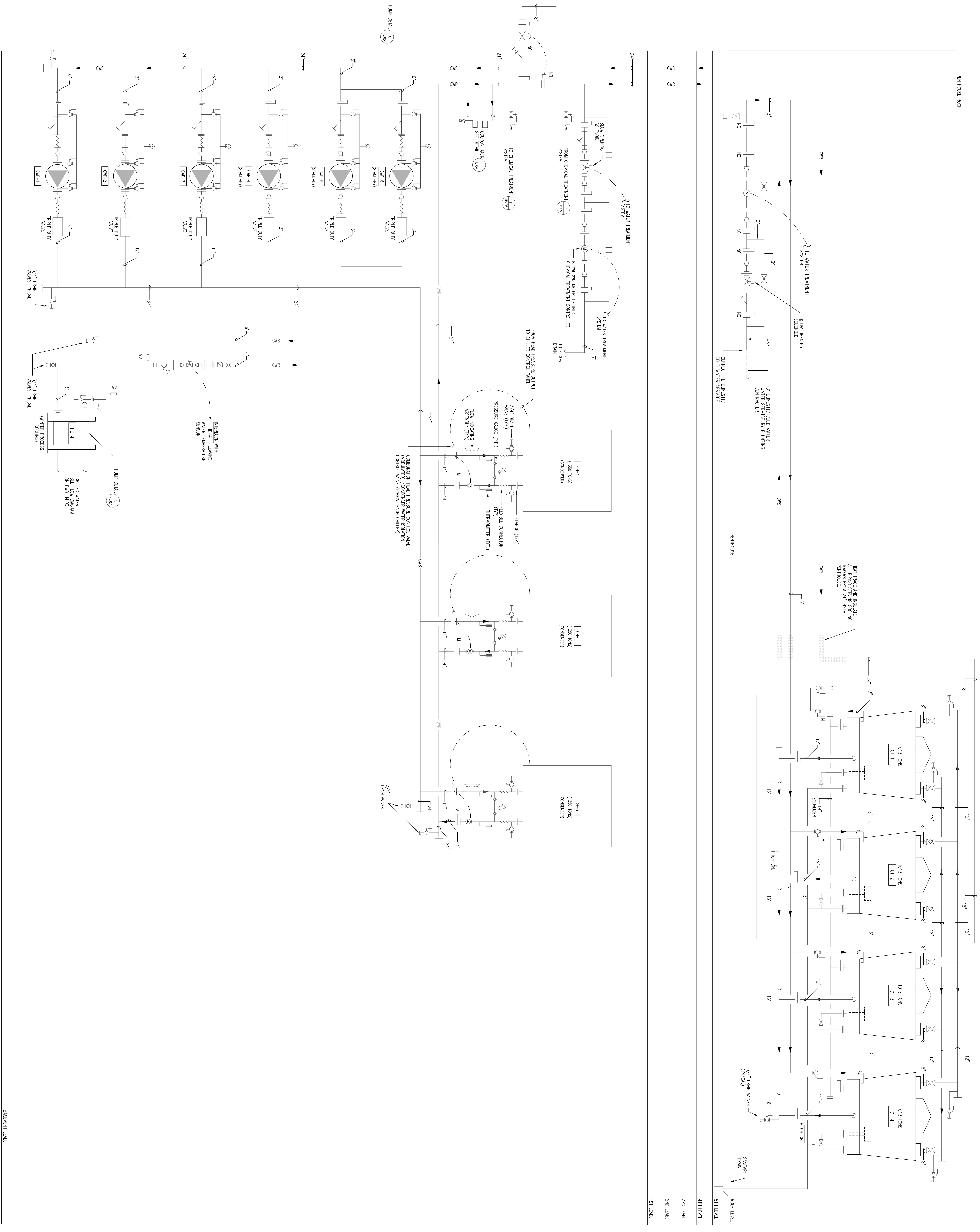
# HOT WATER SCHEMATIC



# CHILLED WATER SCHEMATIC



# CONDENSER WATER SCHEMATIC











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## BUILDING MECHANICAL OPERATION DISCRIPTION

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NOTE: See the corresponding schematic and schedules for each section.

### STEAM

Steam service enters through the basement wall as HPS. It first passes through a steam meter; it then branches off into three branches. One branch will directly feed into CP-1. The other two branches will travel through a series of pressure reducing valves PRV-1A and PRV-B for LPS, and PRV-2 for MPS. The LPS will travel directly to the penthouse to HE-1 and HE-2(Stand-By). It will also be distributed to AHU-1, AHU-2, AHU-3, and AHU-4.

The MPS will be distributed to HE-3 and HE-4 in the basement for the building hot water, and to the 2<sup>nd</sup> and 3<sup>rd</sup> floor for autoclaves to sterilize lab equipment.

Condensate is drained to the basement and pumped back to the cogeneration plant by CP-1 through the service pipe which enters next to the steam service pipe.

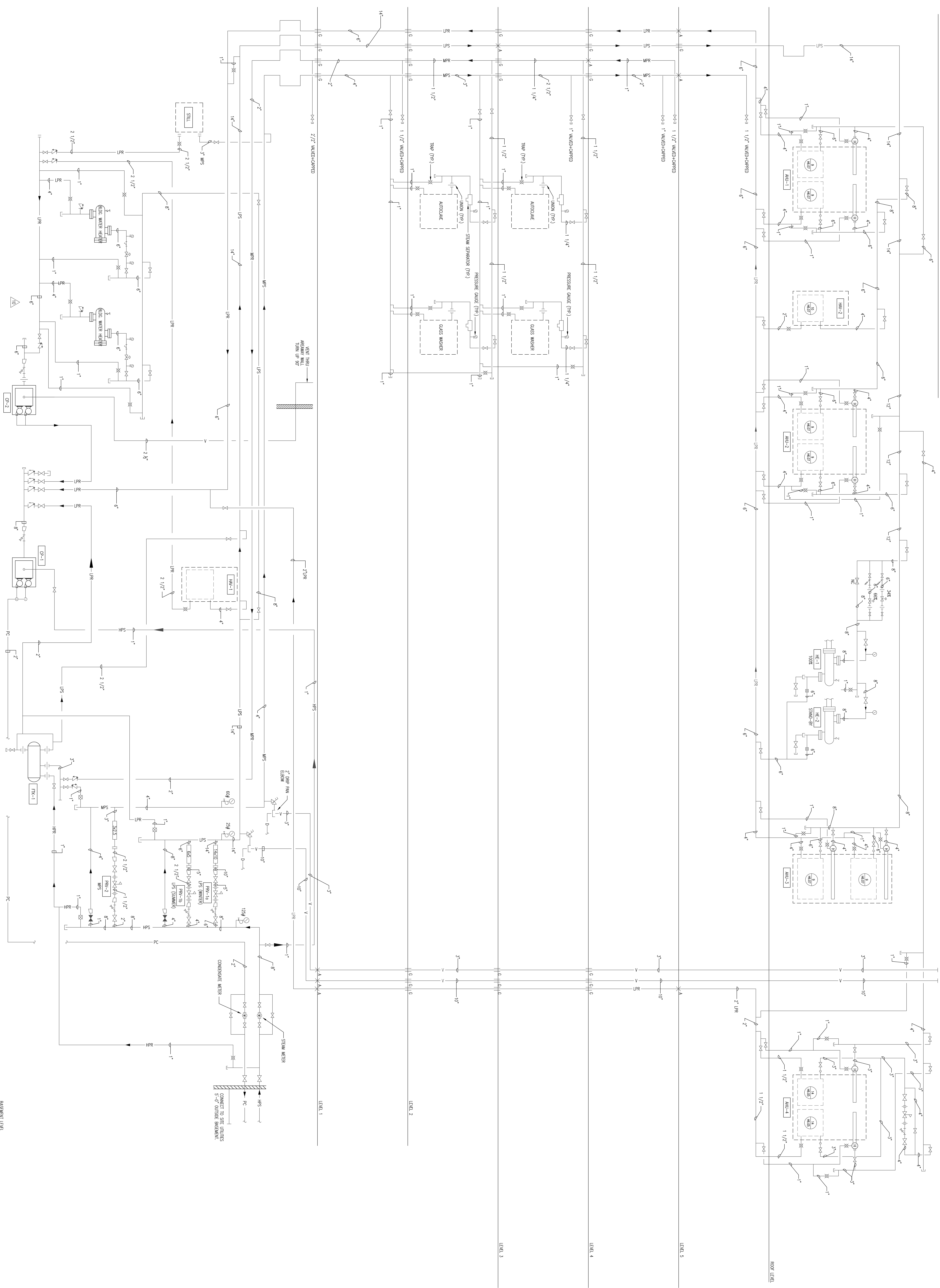
### HOT WATER

Hot water will be generated at HE-1 and HE-2 by LPS. The hot water will first pass through expansion tank TK-1 and an air separator before entering HWP-1 and HWP-2. HWP-1 and HWP-2 pump the hot water to 6 other hot water pumps and 10 outlets on the six levels of the building which feed VAV and CAV boxes. The six hot water pumps supply the building facade. HWP-3, HWP-4, HWP-5 supply the North and South facade VAV and CAV boxes. HWP-6, HWP-7, and HWP-8 supply the East and West facade VAV and CAV boxes.

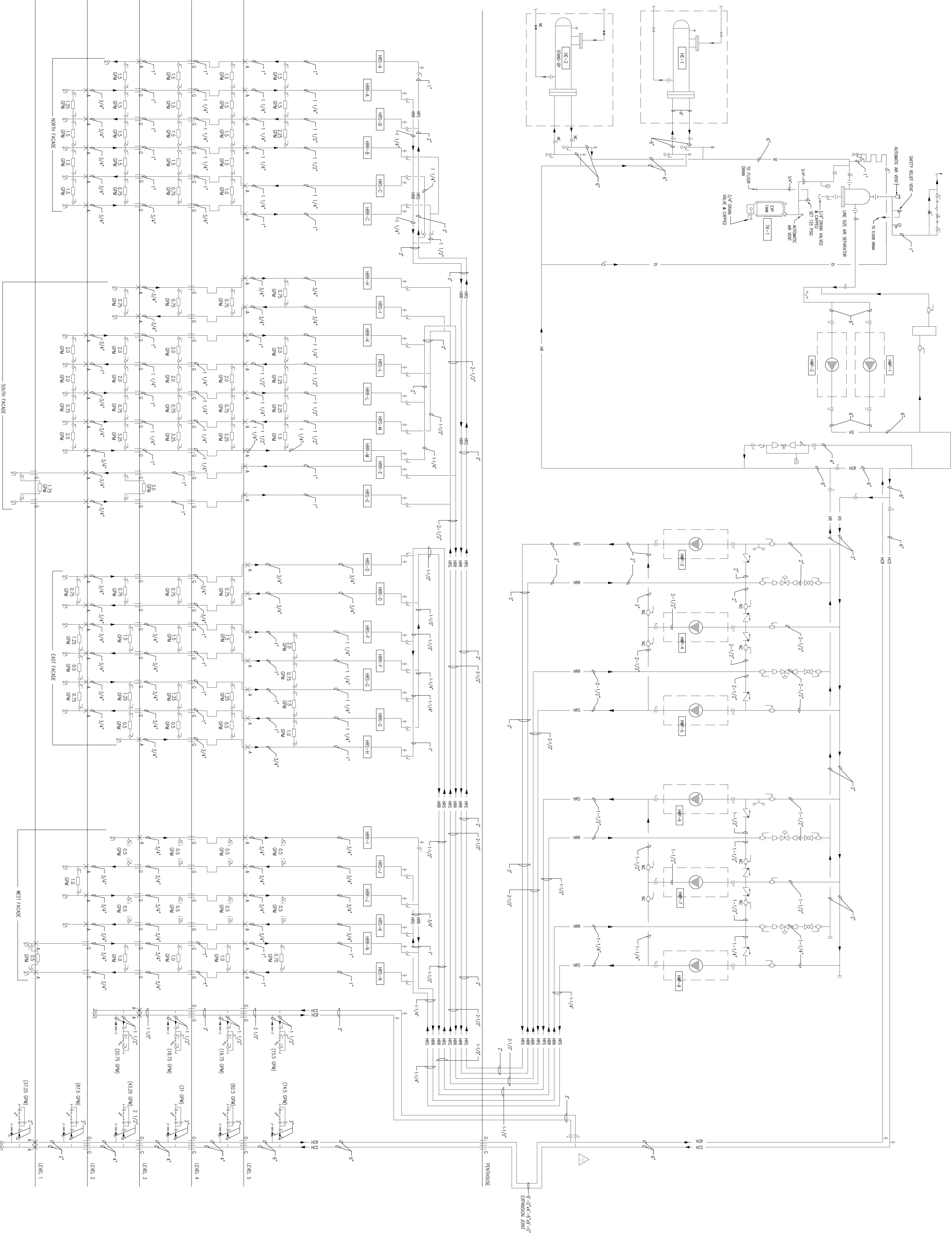
### CHILLED WATER

Chilled water service enters through the basement foundation wall. The chilled water immediately passes through an air separator and expansion tank TK-2. The water then travels to CHP-1, CHP-2, CHP-3, and CHP-4 where it is pumped to CH-1, CH-2, and CH-3 for further cooling. The water is then pumped to AHU-1, AHU-2, AHU-3, and AHU-4 or to PCHP-1 and PCHP-2. Water traveling to the air handlers will pass through the cooling coils for cooling air supplied by the handler. Water traveling to PCHP-1 and PCHP-2 will travel through an air separator and expansion tank TK-3 before traveling to HE-3 and HE-4 for further cooling before continuation on to the VAV and CAV boxes on the 6 building levels.

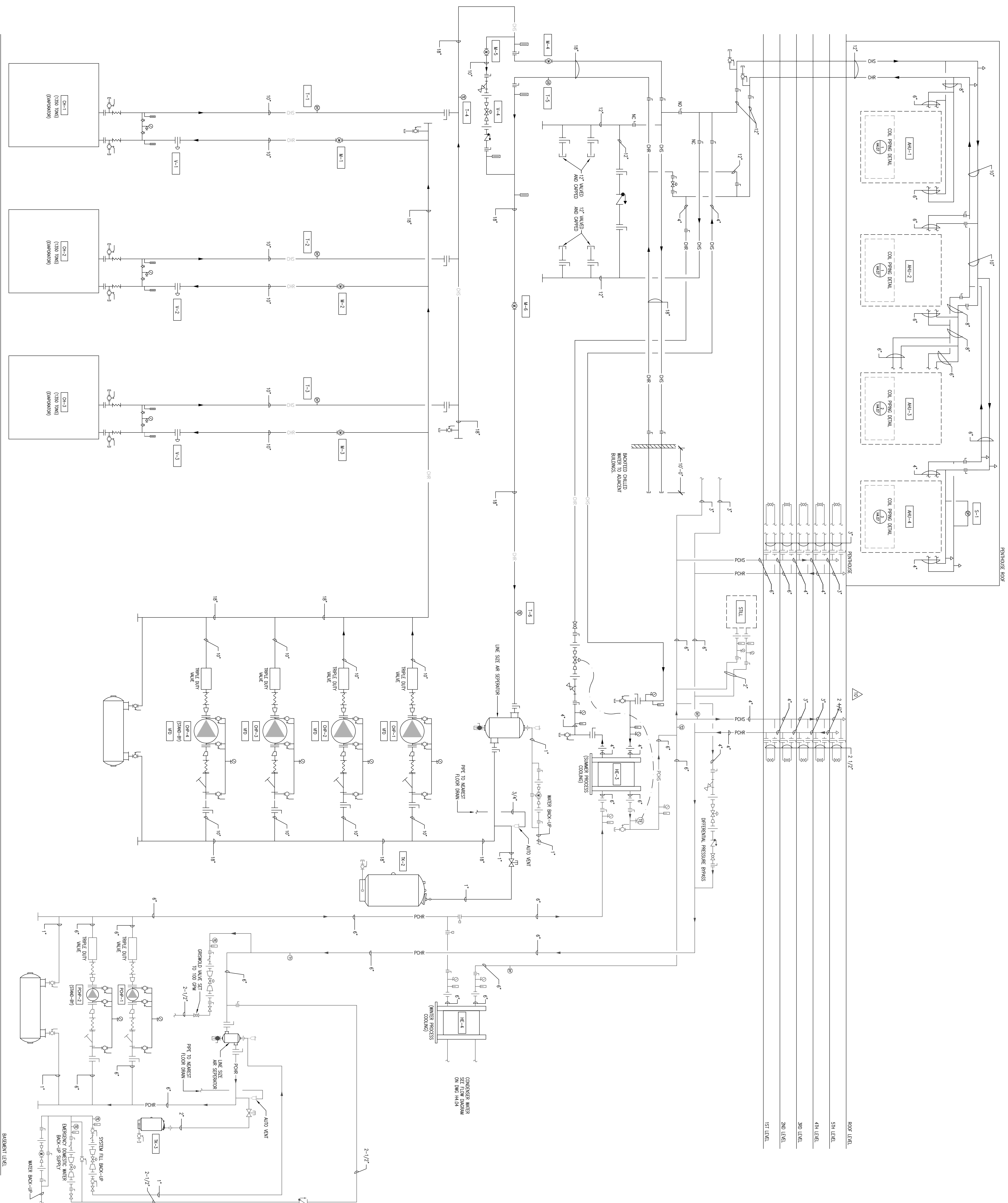
# STEAM SCHEMATIC



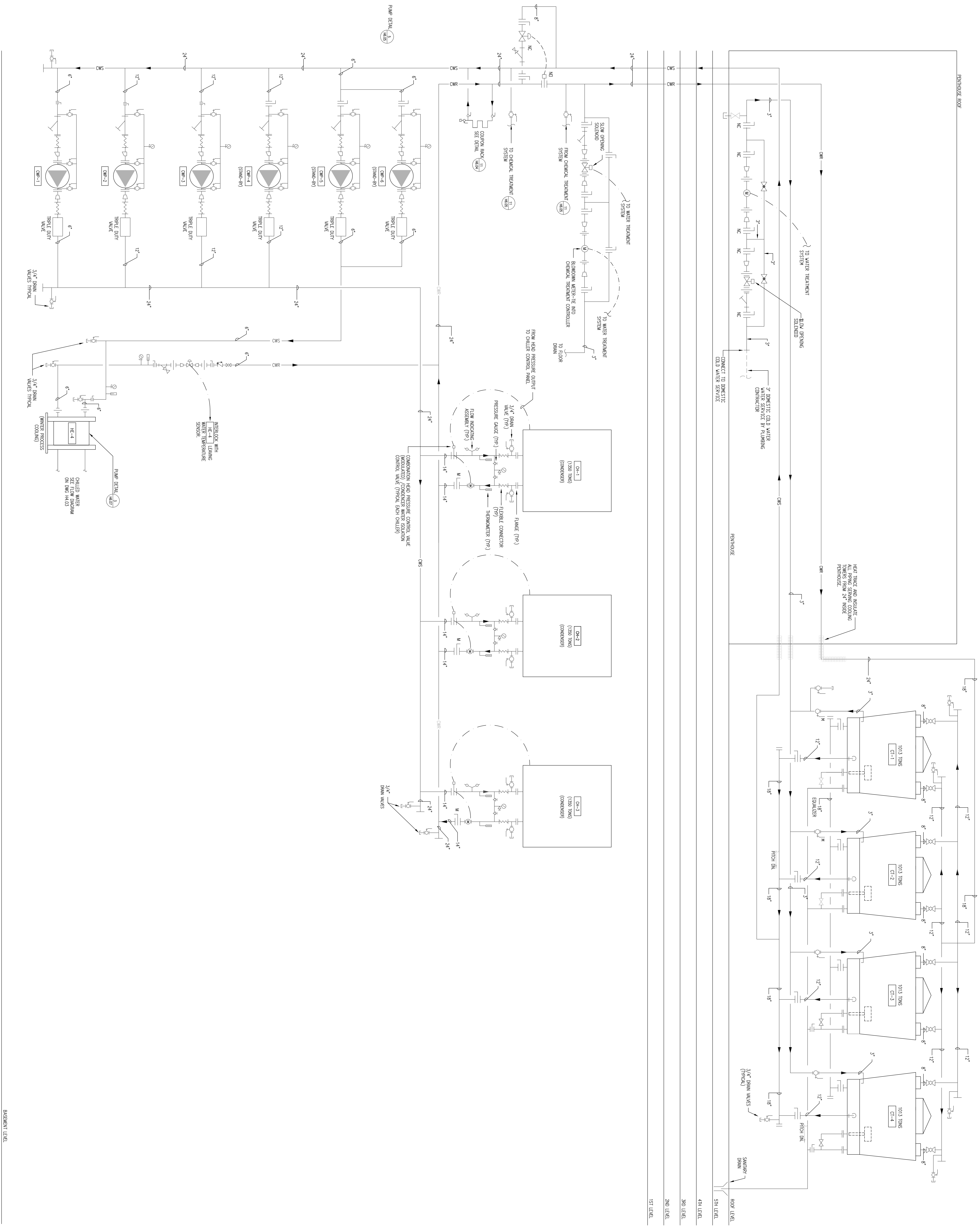
# HOT WATER SCHEMATIC



# CHILLED WATER SCHEMATIC



# CONDENSER WATER SCHEMATIC











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### CONDENSER WATER

Condenser water is supplied to the mechanical equipment in the basement using 6 pumps. CWP-1, CWP-2, CWP-3, and CWP-4 supply condenser water to CH-1, CH-2, and CH-3. CWP-5 and CWP-6 supply the heat exchanger HE-4 which conditions chilled water traveling to the VAV and CAV boxes. The returned condenser water from the mechanical equipment is then pumped to the roof where it will be reconditioned by cooling towers CT-1, CT-2, CT-3, and CT-4 before returning to the pump stations.

### CONDITIONED/EXHAUSTED AIR

Conditioned air is supplied from four air handlers AHU-1, AHU-2, AHU-3, and AHU-4. Each air handler has a designated area which it supplies; these areas can be seen in the zone diagrams preceding this section. The air is supplied to each level through one of three central mechanical shafts. The amount of air supplied to each level can be seen in the Air Flow Schematic.

Air is continuously exhausted from laboratory areas on each level. Each run of exhausted air travels to the penthouse where it is exhausted into a plenum. The plenum air is then exhausted through the roof through an exhaust stack.



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## CRITIQUE OF SYSTEMS

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The building system used in the Chemistry Building is very common for new construction on the Pennsylvania State University, University Park campus. The building integrates with existing components of the university for heating and cooling. The use of the central chiller plant and cogeneration steam has greatly reduced need of energy for heating and cooling.

Problems do exist with the mechanical system; one such problem is part time load conditions. The heating coils used in the AHU s are integral face and bypass damper type. The problem which exists at part time load is that the bypass damper wings do not function at the proper range. Meaning either they are closed to far, no letting the proper amount of air pass through resulting in cooler temperatures than desired. Or the bypass damper wings are open to far resulting in warmer temperatures than desired. If this problem with thermal comfort could be addressed, building satisfaction would reach 100, or close to it.

Overall, the Chemistry Building is fashionably integrated into the Penn State campus. Its design avoided disrupting historic sites and pedestrian traffic paths between buildings, while creating its own pedestrian path between itself and its sister building Life Science. In addition the building takes full advantage of the already existing systems in place. The Chemistry Building is a great addition to the Penn State Campus at University Park.



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