MECHANICAL SYSTEMS EXISTING CONDITIONS

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NATIONAL AUDIO VISUAL CONSERVATION CENTER

CULPEPER COUNTY, VA

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1. EXECUTIVE SUMMARY

The NAVCC is designed to serve many functions including storage, conservation, and enjoyment of all media types. This 400,000 square foot facility is designed to ensure the protection of the all media to pass through and reside in within its walls. This includes very intense cooling and dehumidification systems, 100 % out door air systems, many levels of redundancy, and a vast range of controls and monitoring devices. Provided in this report is a summary of each system used to maintain the functionality of each space, ventilation requirements, space design criterion, heating and cooling load calculations, energy model results, and schematic and operation information. The result will provide an understanding of each system, space, and how they interact with each other.

2. VENTILATION REQUIREMENTS

2.1. Collections Desiccant AHU

AHU 1-1 and 1-2 represent the typical pair of units that supply a region of the Collection Vaults. These units are each constant air volume dessicant units supplying 20,000 CFM each. Since the content of the vaults is sensitive, each unit is capable of supplying 100% Outdoor air for smoke evacuation purposes. In this case the ventilation rate is driven primarily by the requirements for the content of the vaults, the 15% outdoor air that each unit supplies is enough for each unit to meet the standard 62 requirements as shown in the table 2-1.

Project Name	NAVCC
System Tag	AHU 1-1 & 1-2
Location	4th Floor Collections, Part C
Service	Collections Vaults
Design Total CFM	20000 CFM Each
Design OA CFM	3000 CFM Each
% OA	15%

A_z	Floor Area (SF)	V_{pz}	Primary airflow (w/o local recirculation)
P_z	Maximum # of Occupants	V_{dz}	Supply airflow (incl. local recirculation)
R_a	OA per ft^2 (CFM/SF)	V_{dzm}	Minimum airflow
R_p	OA per person (CFM/person)	Z_p	OA Fraction
A_z*R_a	Uncorrected CFM/SF	E_v	Ventilation Efficiency
P_z*R_p	Uncorrected CFM/Person	E_z	Zone air dist effectiveness
V_{oz}	Corrected OA = $A_z*R_a + P_z*R_p/E_z$		

Room Name	Room Type	A_z	P_z	R_a	R_p	A_z*R_a	P_z*R_p	E_z	V_{oz}	V_{pz}	V_{dz}	Z_p
Future Development	Bank vaults/safe deposit	5457	1	0.06	5	327	5	1	332	8850	10050	0.038
Electric Room	Storage rooms	48	0	0.12	0	6	0	1	6	75	75	0.077
Security Room	Office space	48	1	0.06	5	3	5	1	8	75	75	0.105
Corridor	Corridors	1580	0	0.06	0	95	0	1	95	1320	1320	0.072
NFPA Vault 1218	Bank vaults/safe deposit	2304	1	0.06	5	138	5	1	143	2460	2460	0.058
NFPA Vault 1227	Bank vaults/safe deposit	1440	1	0.06	5	86	5	1	91	1880	1880	0.049
NFPA Vault 1225	Bank vaults/safe deposit	1440	1	0.06	5	86	5	1	91	1880	1880	0.049
NFPA Vault 1223	Bank vaults/safe deposit	1760	1	0.06	5	106	5	1	111	1810	1810	0.061
Electric Room	Storage rooms	48	0	0.12	0	6	0	1	6	100	100	0.058
Security Room	Office space	48	1	0.06	5	3	5	1	8	100	100	0.079
Unoccupied		692	0	N/A	N/A	0	0	1	0	140	140	0.000
Vault 1116	Bank vaults/safe deposit	2000	1	0.06	5	120	5	1	125	2700	2700	0.046
Vault 1118	Bank vaults/safe deposit	2000	1	0.06	5	120	5	1	125	2700	2700	0.046
Vault 1113	Bank vaults/safe deposit	2576	1	0.06	5	155	5	1	160	2700	2700	0.059
Vault 1120	Bank vaults/safe deposit	2000	1	0.06	5	120	5	1	125	2700	2700	0.046
Vault 1122	Bank vaults/safe deposit	2000	1	0.06	5	120	5	1	125	2700	2700	0.046
Vault 1115	Bank vaults/safe deposit	2240	1	0.06	5	134	5	1	139	3000	3000	0.046
Vault 1117	Bank vaults/safe deposit	1440	1	0.06	5	86	5	1	91	2850	2850	0.032
Corridor	Corridors	1260	0	0.06	0	76	0	1	76	1110	1110	0.068

Ps	System Population	5
D	Occupant Diversity Ratio	0.36
V_{ou}	Uncorrected OA intake	708
$Z_{p,max}$	Max Z_p	0.105
Ev	Ventilation Efficiency	1
V_{OT}	System OA intake	708
V_{PS}	System primary supply	39150
X_s	System Mixed Air Ratio	0.018

Table 2-1 Desiccant AHU Ventilation Summary

2.2. Collections Low Temperature Desiccant AHU

The function of these units is to serve the low temperature vaults housing the motion picture storage. Like the standard collection vault units, these air handlers are also constant air volume dessicant units. They supply 9000 CFM of 32 degree air which is then cooled by recooling coils and served to the space at 15 degrees. Since there is a very low occupancy load on these units, the 12% outdoor air that is supplied by the unit meets the ASHRAE 62 requirements when diversity is applied.

Project Name	NAVCC
System Tag	AHU 1-7 & 1-8
Location	4th Floor Collections
Service	Low Temp Vaults
Design Total CFM	9000 CFM Each
Design OA CFM	1120 CFM Each
% OA	12%

A_z	Floor Area (SF)	V_{pz}	Primary airflow (w/o local recirculation)
P_z	Maximum # of Occupants	V_{dz}	Supply airflow (incl. local recirculation)
R_a	OA per ft^2 (CFM/SF)	V_{dzm}	Minimum airflow
R_p	OA per person (CFM/person)	Z_p	OA Fraction
A_z*R_a	Uncorrected CFM/SF	E_v	Ventilation Efficiency
P_z*R_p	Uncorrected CFM/Person	E_z	Zone air dist effectiveness
V_{oz}	Corrected OA = A_z*R_a + P_z*R_p/E_z		

Room Name	Room Type	A_z	P_z	R_a	R_p	A_z*R_a	P_z*R_p	E_z	V_{oz}	V_{pz}	V_{dz}	Z_p
Corridor	Corridors	312	0	0.06	0	19	0	1	19	190	190	0.099
Vault 1102	Bank vaults/safe deposit	2552	1	0.06	5	153	5	1	158	4440	4440	0.036
Unoccupied		1120	0	0	0	0	0	1	0	160	160	0.000
Vault 1104	Bank vaults/safe deposit	2816	1	0.06	5	169	5	1	174	4800	4800	0.036
Vestibule	Corridors	240	4	0.06	0	14	0	1	14	200	200	0.072
Vault 1106	Bank vaults/safe deposit	2848	1	0.06	5	171	5	1	176	3375	3375	0.052
Vault 1108	Bank vaults/safe deposit	1392	1	0.06	5	84	5	1	89	2000	2000	0.044
Vault 1110	Bank vaults/safe deposit	2264	1	0.06	5	136	5	1	141	2835	2835	0.050

Ps	System Population	3
D	Occupant Diversity Ratio	0.33
V_{ou}	Uncorrected OA intake	273
$Z_{p,max}$	Max Z_p	0.099
Ev	Ventilation Efficiency	1.0
V_{OT}	System OA intake	273
V_{PS}	System primary supply	18000
X_s	System Mixed Air Ratio	0.015

Table 2-2 Low Temperature AHU Ventilation Summary

2.3. VAV AHU

This air handling unit is one of the few typical units in the building. Because it serves primarily office spaces it is a variable air volume unit serving 22,500 CFM with a minimum of 25% is outdoor air. Since this building was designed following ASHRAE standard 62.1 2001, the outdoor air requirements vary somewhat due to the higher ventilation rate per person and the lack of ventilation per square foot. Although this causes the ventilation rates to be low in spaces such as storage rooms, the overall system still meets Standard 62.1 2004.

Project Name	NAVCC
System Tag	AHU 2-1
Location	4th Floor Collections
Service	Conservation 3rd Floor Office
Design Total CFM	22500 CFM Each
Design OA CFM	5700 CFM Each
% OA	25%

A_z	Floor Area (SF)	V_{pz}	Primary airflow (w/o local recirculation)
P_z	Maximum # of Occupants	V_{dz}	Supply airflow (incl. local recirculation)
R_a	OA per ft^2 (CFM/SF)	V_{dzm}	Minimum airflow
R_p	OA per person (CFM/person)	Z_p	OA Fraction
A_z*R_a	Uncorrected CFM/SF	E_v	Ventilation Efficiency
P_z*R_p	Uncorrected CFM/Person	E_z	Zone air dist effectiveness
V_{oz}	Corrected OA = A_z*R_a + P_z*R_p/E_z		

Room Name	Room Type	A_z	P_z	R_a	R_p	A_z*R_a	P_z*R_p	E_z	V_{oz}	V_{pz}	V_{dz}	Z_p
Open Office	Office space	9000	45	0.06	5	540	225	1	765	10375	3112.5	0.246
Tape Bake	Photo studios	112	2	0.12	5	13	10	1	23	205	61.5	0.381
Tape Prep	Photo studios	180	2	0.12	5	22	10	1	32	200	60	0.527
Disc Prep	Photo studios	700	7	0.12	5	84	35	1	119	795	238.5	0.499
Clean Holding	Storage rooms	96	0	0.12	0	12	0	1	12	90	27	0.427
Storage	Storage rooms	210	0	0.12	0	25	0	1	25	200	60	0.420
Stair Press		N/A	0	0	0	0	0	1	0	650	195	0.000
Corridor	Corridors	320	0	0.06	0	19	0	1	19	160	48	0.400
Storage	Storage rooms	80	0	0.12	0	10	0	1	10	95	28.5	0.337
Corridor	Corridors	350	0	0.06	0	21	0	1	21	195	58.5	0.359
Holding	Storage rooms	220	0	0.12	0	26	0	1	26	185	55.5	0.476
Tape Rewind	Office space	300	2	0.06	5	18	10	1	28	285	85.5	0.327
Corridor	Corridors	1632	0	0.06	0	98	0	1	98	1820	546	0.179
Office	Office space	300	2	0.06	5	18	10	1	28	300	90	0.311
Video Edit	Office space	456	3	0.06	5	27	15	1	42	400	120	0.353
Lab Head	Office space	143	1	0.06	5	9	5	1	14	110	33	0.412
CTO/P	Office space	143	1	0.06	5	9	5	1	14	110	33	0.412
D 3102	Office space	276	2	0.06	5	17	10	1	27	210	63	0.422
A/V Maintenance	Office space	552	3	0.06	5	33	15	1	48	430	129	0.373
Section Head	Office space	415	2	0.06	5	25	10	1	35	260	78	0.447
Research Fellow	Office space	1380	7	0.06	5	83	35	1	118	2050	615	0.192
Conference	Conference / meeting	256	6	0.06	5	15	30	1	45	740	222	0.204
Equipment	Storage rooms	728	0	0.12	0	87	0	1	87	470	141	0.620
Media Prep	Photo studios	550	6	0.12	5	66	30	1	96	800	240	0.400
Restrooms		624	0	0	0	0	0	1	0	300	90	0.000
Expansion	Office space	3520	18	0.06	5	211	90	1	301	3800	1140	0.264
Screening	Media Center	2050	10	0.12	10	246	100	1	346	2000	600	0.577
Corridor	Corridors	288	0	0.06	0	17	0	1	17	150	45	0.384

Ps	System Population	119
D	Occupant Diversity Ratio	1.00
V_{ou}	Uncorrected OA intake	2396
$Z_{p,max}$	Max Z_p	0.620
Ev	Ventilation Efficiency	0.6
V_{OT}	System OA intake	3993
V_{PS}	System primary supply	27385
X_s	System Mixed Air Ratio	0.146

Table 2-3 VAV AHU Ventilation Summary

2.4. Nitrate Vault Desiccant AHU

Due to the small size of the vaults in the Nitrate Building, each vault will rarely experience any occupant load. Because of this, diversity has a large effect on the ventilation requirements, and again the ventilation rates are determined mainly due to the content of the vaults. Therefore, each AHU supplying 20,000 CFM at 10 % outdoor air meet the requirements set in ASHRAE Standard 62 2004.

Project Name	NAVCC
System Tag	AHU 3-1 & 3-2
Location	Nitrate Vaults Mech Room
Service	Nitrate Vaults Mech Room
Design Total CFM	20000 CFM Each
Design OA CFM	2000 CFM Each
% OA	10%

A_z	Floor Area (SF)	**V_{pz}**	Primary airflow (w/o local recirculation)
P_z	Maximum # of Occupants	**V_{dz}**	Supply airflow (incl. local recirculation)
R_a	OA per ft^2 (CFM/SF)	**V_{dzm}**	Minimum airflow
R_p	OA per person (CFM/person)	**Z_p**	OA Fraction
A_z*R_a	Uncorrected CFM/SF	**E_v**	Ventilation Efficiency
P_z*R_p	Uncorrected CFM/Person	**E_z**	Zone air dist effectiveness
V_{oz}	Corrected OA = A_z*R_a + P_z*R_p/E_z		

Room Name	Room Type	A_z	P_z	R_a	R_p	A_z*R_a	P_z*R_p	E_z	V_{oz}	V_{pz}	V_{dz}	Z_p
Vaults	Bank vaults/safe deposit	13330	124	0.06	5	800	620	1	1420	31000	31000	0.046
Corridor	Corridors	2960	0	0.06	0	178	0	1	178	4810	4810	0.037

Ps	System Population	3
D	Occupant Diversity Ratio	0.02
V_{ou}	Uncorrected OA intake	644
$Z_{p,max}$	Max Z_p	0.046
Ev	Ventilation Efficiency	1.0
V_{OT}	System OA intake	644
V_{PS}	System primary supply	35810
X_s	System Mixed Air Ratio	0.018

Table 2-4 Nitrate Vault AHU Ventilation Summary

3. DESIGN INFORMATION & CALCULATIONS

Using Trane TRACE, an energy model of the NAVCC has been created to determine space heating and cooling loads as well as total annual energy consumption of the building mechanical systems. This section provides a summary of the input data used to model the building, a comparison of the calculated and design loads, and a discussion of the resulting energy model. While an energy analysis was unable to be obtained the calculated peak loads will be compared to the scheduled equipment to determine accuracy of the model.

3.1. Design Criteria

The space design criteria is determined by the function of each space. Since each different types of film have separate requirements for ambient conditions, the space requirements vary throughout the buildings. Table 3-1 summarizes space criteria for typical space types.

Space Design Criteria			
Space	**DBT (F) Summer/Winter**	**RH (%) Summer/Win**	**HR (gr/lb) Summer/Win**
Office Area	75/70 ±2	50/40 ±5	65/43
Photographic Lab	75/70 ±2	50/40 ±5	65/43
Collections Holding	68 ±2	50 Max	50 Max
Collections Storage	50 ±5	35 ±5	19
Nitrate Film Storage	39 ±5	30 ±5	10
Motion Picture Storag	25 ±5	30 ±5	6

Table 3-1 Space Design Criterion Summary

4. ENERGY MODEL INPUT DATA

In addition to space criteria data provided above, Table 4-1 summarizes the input data for each space type. Room areas, wall dimensions, and building construction data were collected from the drawings while interior design conditions and equipment data was obtained from documents courtesy of Vanderweil Engineers.

Energy Model Input Data				
Space Type	**Lighting Levels**	**Equipment Levels**	**Occupancy**	**Ventilation**
Office Area	2	3	143 SF/pers	20 CFM/pers
Photographic Lab	2	4	33 SF/pers	100% CFM
Collections Holding	2.8	0	0	0.05 CFM/SF
Collections Storage	2.8	0	0	0.05 CFM/SF
Nitrate Film Storage	2.8	0	0	0.05 CFM/SF
Motion Picture Storage	2.8	0	0	0.05 CFM/SF
A/V Lab	2	6	33 SF/pers	20 CFM/pers
Screening Rooms	3	3	8SF/pers	15 CFM/pers

Table 4-1

Table 4-2 Energy Input Summary

5. HEATING AND COOLING LOAD CALCULATION RESULTS

Once essential data was collected, a Trane TRACE energy model was run to determine equipment loading and energy consumption. Where the majority of the calculated data was comparable to the design documents, some systems differed from the provided information. Table 5-1 provides a summary of the energy model comparisons. The difference in values may be due to system complexities that were compromised in the energy model. If a more accurate model should be needed a more advanced program may be required. Additionally, areas and dimensions taken by hand could account for some inaccuracy.

System Energy Model Comparisons

System Tag	Total Area (SF)	Calculated Data					Design Data				
		Cooling Ton	CFM	%OA	CFM/ SF	CFM/T on	Cooling Ton	CFM	%OA	CFM/ SF	CFM/ Ton
AHU 1-1&2	31,111	35.1	40231	4	1.29	860.3	73.8	40000	15	1.29	542
AHU 1-3&4	31,117	31.4	34521	4	1.11	811.9	73.8	40000	15	1.29	542
AHU 1-5&6	29,768	28.2	30639	5	1.03	783.2	73.8	40000	15	1.34	542
AHU 1-7&8	13,544	18.1	23639	3	1.75	930.5	20	18000	12	1.33	900
AHU 1-9	6,950	13.1	3333	25	0.48	254.9	31	9500	11	1.37	306
AHU 1-10	620	2.2	1242	0	2	573.7	4	2000	0	3.23	500
AHU 2-1	28,561	73.9	18591	27	0.65	251.7	71	22500	25	0.79	317
AHU 2-1A	12,214	39.8	15356	11	1.26	385.5	54	33300	26	2.73	617
AHU 2-2&3	21,629	153.4	23072	100	1.07	150.4	130	60000	100	2.77	462
AHU 2-4	26,587	152.3	25225	69	0.95	165.6	30	14500	17	0.55	483
AHU 2-5	18,002	80.5	21723	38	1.21	269.9	25	12000	13	0.67	480
AHU 2-6	12,771	28.8	14550	12	1.14	504.6	30	14500	17	1.14	483
AHU 2-7	19,190	78.1	23065	30	1.2	295.2	35	16000	19	0.83	457
AHU 2-8	1,955	16.4	2467	100	1.26	150.9	10	4000	79	2.05	400
AHU 3-1&2	33,858	42.9	51348	3	1.52	935.5	64	40000	10	1.18	625
FCU 2-1	900	14.6	2422	83	2.69	166.1	3	1200	69	1.33	400
FCU 2-2	550	8.9	1480	83	2.69	166.1	2.3	700	74	1.27	304
FCU 2-3	100	0.1	58	0	0.58	523.4	2.3	900	0	9.00	391
FCU 2-4	100	0.1	58	0	0.58	523.4	1.13	500	0	5.00	442
FCU 2-6	150	0.2	87	0	0.58	523.4	2.3	900	0	6.00	391
FCU 2-7	150	0.2	87	0	0.58	523.4	1.13	500	0	3.33	442
FCU 2-9	160	0.2	115	0	0.72	507.4	1.82	900	0	5.63	495
FCU 2-10	100	0.1	72	0	0.72	507.4	1.13	500	0	5.00	442
FCU 2-11	110	0.2	79	0	0.72	507.4	2.3	1100	0	10.00	478
FCU 2-12	110	0.2	79	0	0.72	507.4	1.13	500	0	4.55	442
FCU 2-13	324	0.5	234	0	0.72	507.4	1.55	1000	0	3.09	645
FCU 2-14	120	0.2	89	0	0.74	479.9	1.13	500	0	4.17	442
FCU 2-15	290	0.4	210	0	0.72	503	2.35	1200	0	4.14	511
FCU 2-16	150	0.2	108	0	0.72	507.4	0.96	500	0	3.33	521
FCU 2-17	150	0.2	108	0	0.72	507.4	1.82	900	0	6.00	495
FCU 2-18	892	0.7	371	0	0.42	507.3	5.5	2400	0	2.69	436
FCU 2-18A	802	0.7	360	0	0.45	507.3	5.5	2400	0	2.99	436
FCU 2-20	90	0.1	65	0	0.72	507.4	0.97	500	0	5.56	515
FCU 2-21	90	0.1	65	0	0.72	507.4	1.82	900	0	10.00	495
FCU 2-22	90	0.1	65	0	0.72	507.4	0.97	500	0	5.56	515
FCU 2-23	90	0.1	65	0	0.72	507.4	1.82	900	0	10.00	495
Totals	**293,395**					**822.3**					**768.33**

Table 5-1 Heating and Cooling Load Calculation Results Summary

6. ANNUAL ENERGY CONSUMPTION

Annual energy consumption estimates were provided with the Trane TRACE calculations. A quick analysis of the results will confirm what can be expected of the NAVCC. Since the space criterion requires very low temperatures in a large percentage of the building, the chiller consumes 51% of the annual HVAC energy consumption at 1,983,200 KWh. With 1,158,479 KWh, fan energy consumes 30% of the annual mechanical load, All HVAC equipment, totaling 3,885,625 KWh, consumes 30% of the total building annual energy consumption. Table 6-1 displays the calculated KWh consumed annually by each equipment category. Graphical representations of the energy distribution are provided in Figures 6-1and 6-2. As the NAVCC has a very atypical nature in both design and functionality, the energy costs can be expected to be larger than a typical office building. In a more detailed analysis it would be important to account for the lighting controls in the vaults. Because all of the vaults are on sensors, the lights will only be on when someone enters. Additionally, timers will shut lights off after the occupant has left. Since the lighting load in the vaults is between 1.7 and 2.8 KW this may have an incredible impact on the energy analysis.

Energy Consumption Summary		
Equipment	**Annual Consumption (KWh)**	**Annual Consumption (Mbtu)**
Fan Equipment	1,158,749	339,610
Chiller/Compressor	1,983,200	581,243
Cooling Towers	365,675	107,173
Cooling Accessories	172,450	50,542
Boiler	200,500	58,763
Htg Accessories	5,051	1,480
HVAC Total	**3,885,625**	**1,138,812**
Lighting	5,094,083	1,492,990
Misc Load	3,922,202	1,149,532
Annual Energy Consumption	**12,901,910**	**3,781,333**
Consumption per Square Foot	**33.62**	**9.85**

Table 6-1 Energy Consumption Summary

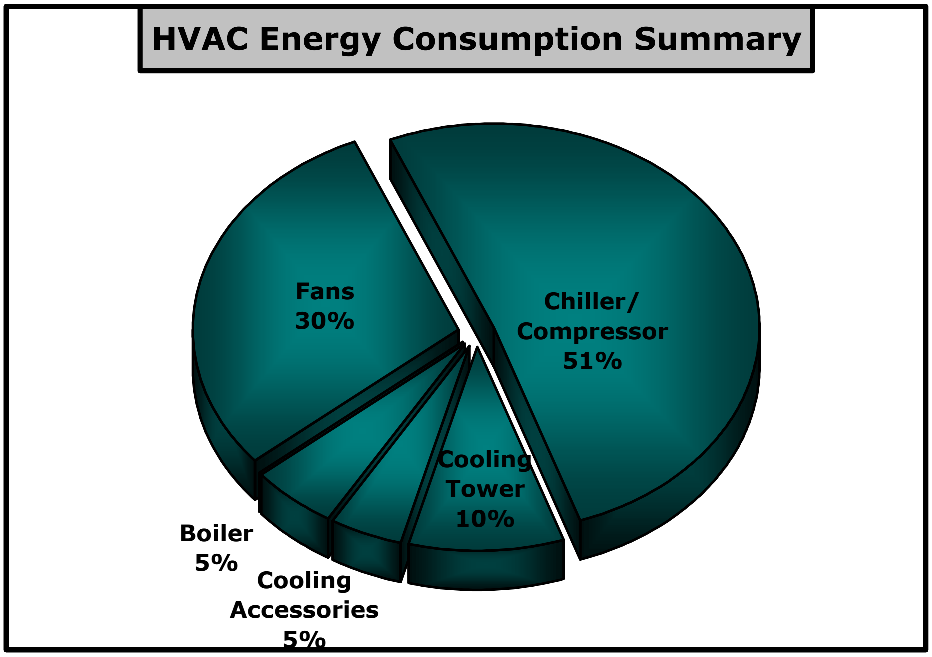


Figure 6-1 HVAC Energy Consumption Summary

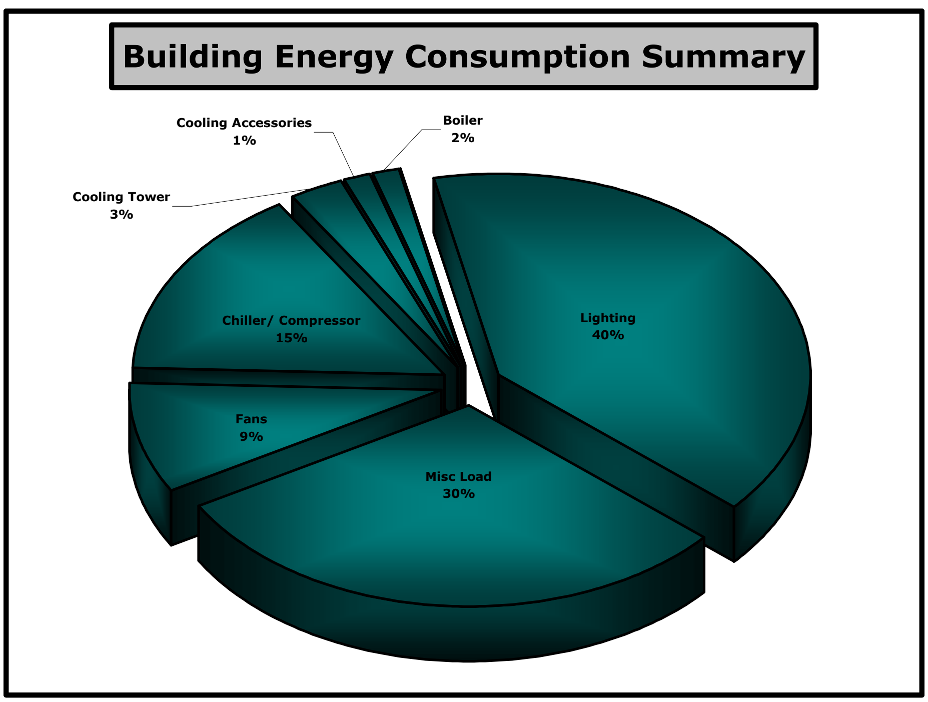


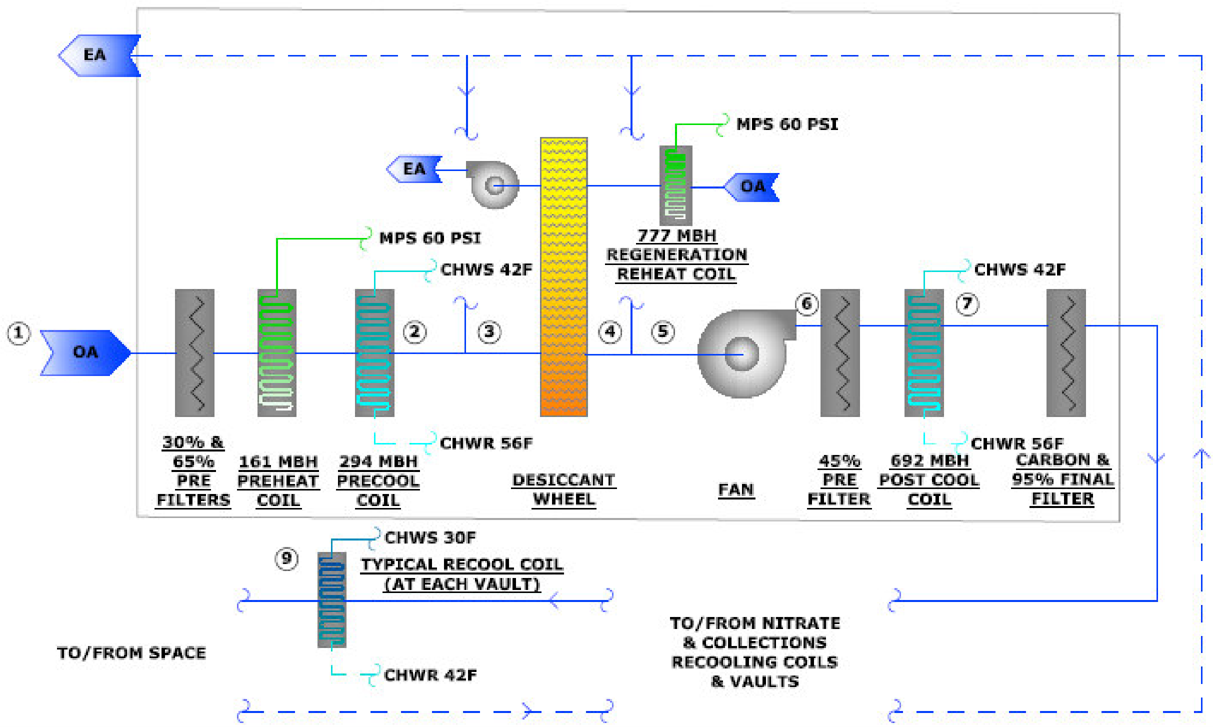
Figure 6-2 Building Energy Consumption Summary

7. SYSTEM SCHEMATICS & OPERATION

7.1. Airside

7.1.1. Desiccant Air Handling Units

7.1.1.1. System Schematics



(1) 3000 CFM, 92 DBT, 131.0 GR/LB	(5) 20000 CFM, 76.7 DBT, 14.5 GR/LB
(2) 3000 CFM, 50.8 DBT, 55.0 GR/LB	(6) 20000 CFM, 83.1 DBT, 14.5 GR/LB
(3) 12000 CFM, 52.1 DBT, 31.4 GR/LB	(7) 20000, 52.1 DBT, 14.5 GR/LB
(4) 12000 CFM, 94.2 DBT, 7.0 GR/LB	(8) *VARIES, 40 DBT, 14.5 GR/LB

Figure 7-1 Desiccant AHU Schematic

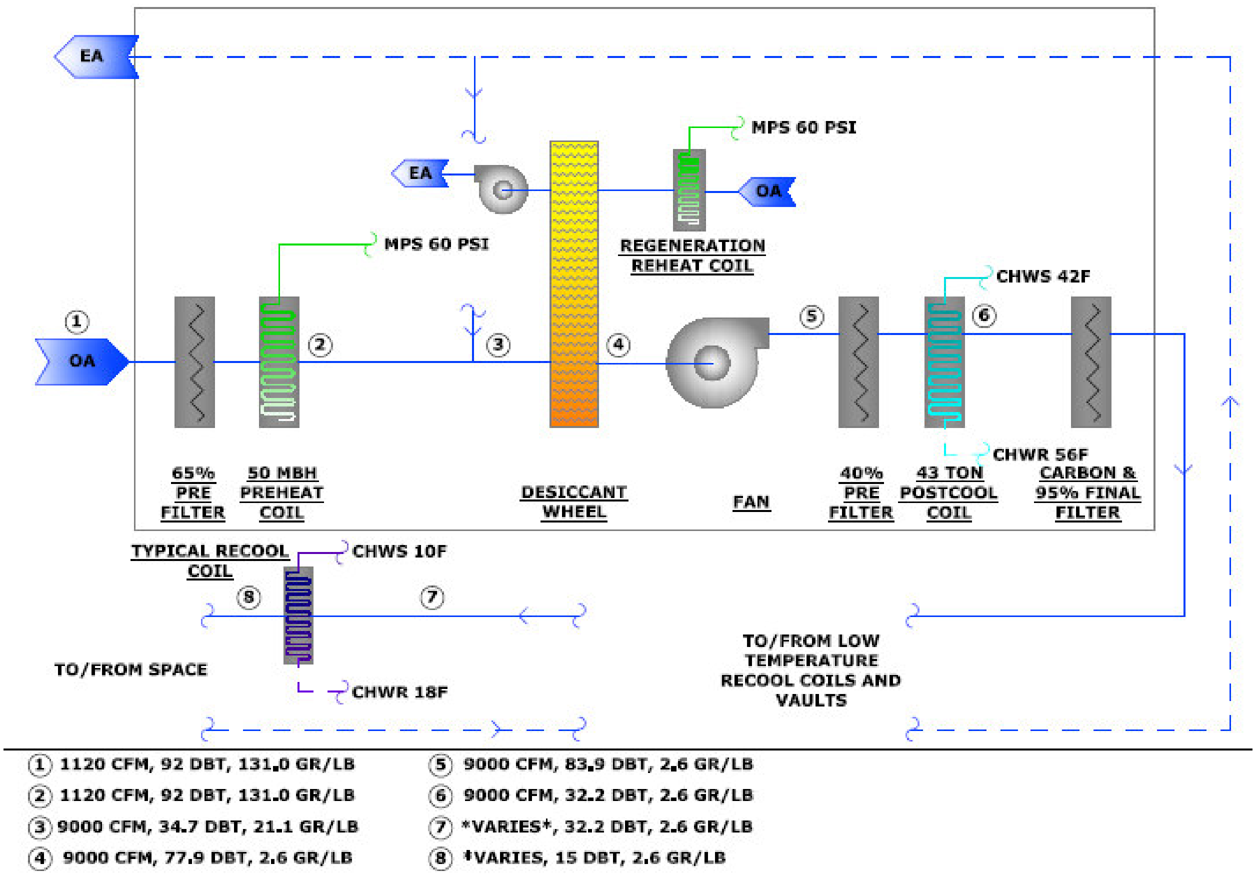


Figure 7-2 Low Temperature Desiccant AHU Schematic

7.1.1.2. System Operation

Both desiccant AHU types operate in a similar manner with an intense concentration on monitoring temperature and humidity in each vault. Figures 7-1 & 7-2 illustrate the process used to condition the outdoor air. Regardless of outdoor air conditions, the DDC will adjust the heating and cooling coil valve positions to maintain 55 F at the temperature sensor located at point 2. Air temperature is also monitored at point 10, the return of each vault. Any rise in temperature will modulate the recooling coil valve to maintain the temperature. In a similar way, the return humidity is monitored at each vault. In this case, any rise in humidity will result in the regeneration reheat coil valve to open. A humidity sensor is located after the final filter to ensure the system stays above the minimum humidity set point.

Alarms are integrated into the system to prevent damage to the contents of the vault. To prevent condensation, if the RCC supply air dew point rises with in 2 F of the chilled water supply temperature, the RCC valve will shut and alarm will sound. The return air is also monitored for smoke detection. In the case of a fire, the system is purged through a bypass around the coils and desiccant wheel. In this case, coil valves are 100% open to prevent freezing.

When the signal for start up is sent, the outdoor air dampers open and the AHU fans start. Once air is flowing through the system, the reactivation dampers open and the desiccant wheel will start. Once the system is operational, the sensors and DCC monitor the conditions described above. Once the system is told to shut down, the AHU fans stop first. Next the AHU dampers and valves close followed by the reactivation dampers and valves. To prevent stopping and starting of the wheel, a three minute delay occurs before the desiccant wheel motor and fans will stop.

7.1.2. Variable Air Volume Air Handling Units

7.1.2.1. System Schematic

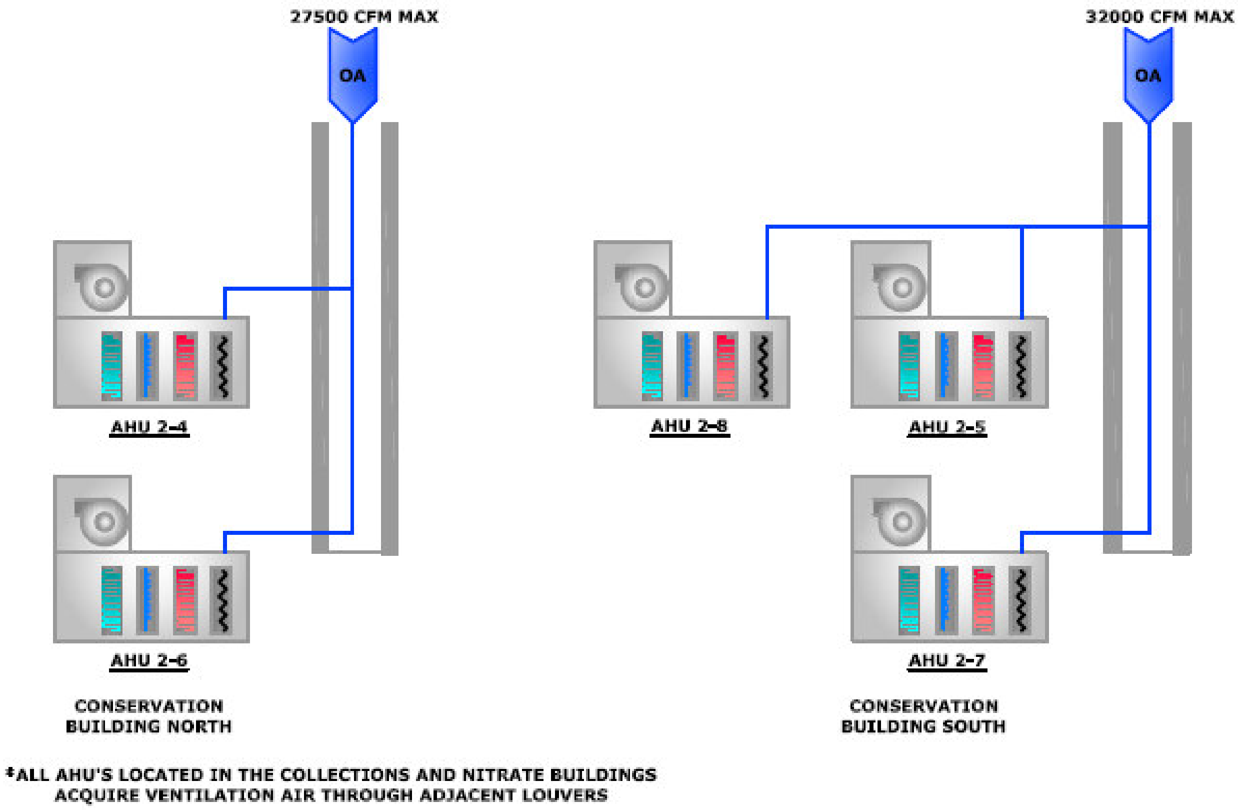


Figure 7-3 OA & VAV AHU Schematic

7.1.2.2. System Operation

Most of the non vault or lab space is served air through fairly typical VAV air handling units. Much simpler than the desiccant units, these units typically include a mixing box, filter, preheat coil, humidifier, cooling coil, and a fan. Shown in figure 7-3 is a typical layout for such a unit.

To minimize energy consumption, an enthalpy controlled economizer has been utilized. If the enthalpy sensor for the return air is greater than the sensor for the outdoor air then the economizer mode will be activated. Shut off will occur when the temperature sensor at the mixing box is less than 45 F. Additionally, when the relative humidity at point 6 drops below 50% for more than 10 minutes and the outdoor air temperature is less than 50 F, the humidifier valve will increase flow.

To protect the unit as well as the spaces it serves, there are a number of controls specified for the system. If after the preheat coil, the temperature drops below 40 F, the DCC will trigger the unit to shut off. The system will also experience a shut of when smoke is detected in the return air ductwork as well as if no airflow is detected.

7.2. Waterside

7.2.1. Chilled Water

7.2.1.1. System Schematic

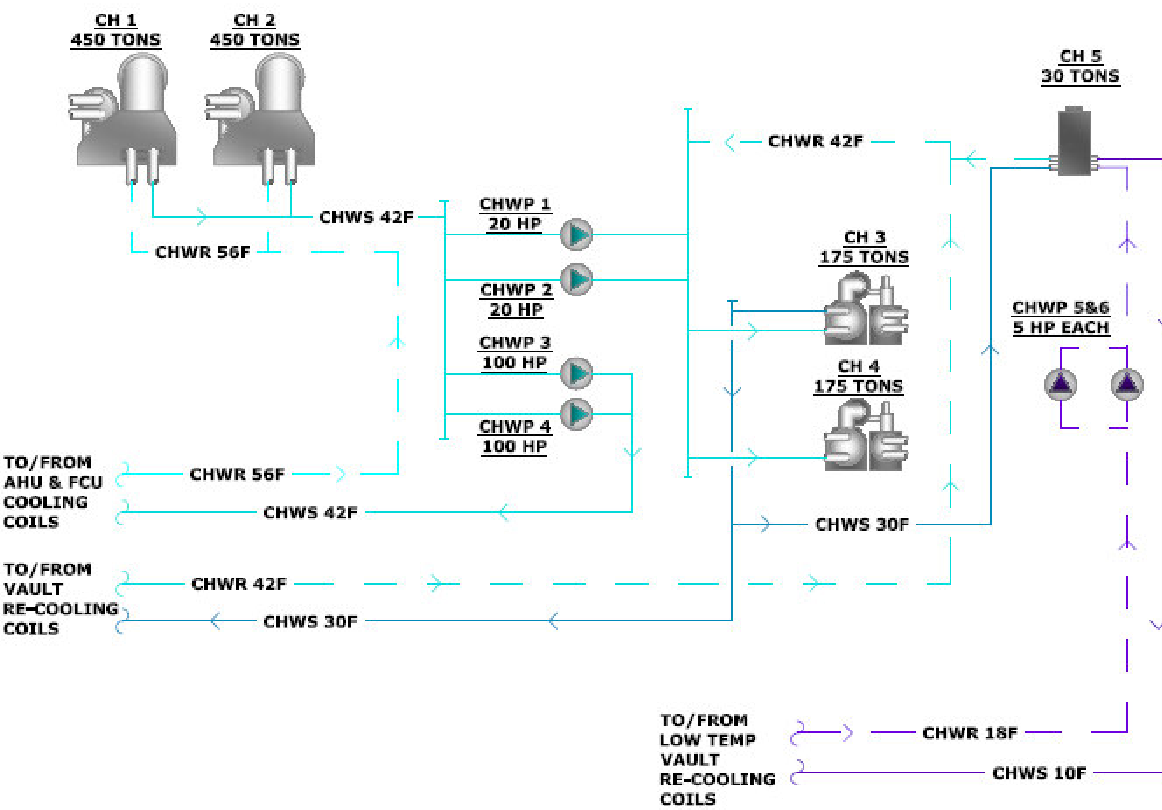


Figure 7-4 Chilled Water Schematic

7.2.1.2. System Operation

The Chilled water system as seen in figure 7-4, is compromised of two 450 ton centrifugal chillers (CH 1 & 2) operating in series with two 175 ton rotary screw chillers (CH 3 & 4). Chillers 1 & 2 operate on a 42 to 56 degree loop while the chillers 3 & 4 are supplied with the 42 F water and supply 30 F to the RCC's at the vaults. Additionally, a 30 ton scroll compressor chiller rejects the heat from its 10 to 18 degree loop to the 30 F water. The variable primary system supplies the various degrees of chilled water via six VSD pumps.

Once the signal to start the chiller sequencing has been received, the isolation valves to the lead chiller pair are opened and the lead chilled water pumps are started. After the pumps have ramped up to the minimum speed required for the chiller to function, the lead chiller pair will be turned on. Each chiller pair consist of one 450 ton and one 175 ton chiller (ie CH 1 & CH 3). In order to equalize run time of the pairs, the direct digital control (DDC) system tracks the run time of each pair to determine the next lead pair. When the lead chiller pair maintains 100% load for over five minutes, the DDC will start the lag pumps and chiller pair. When the second chiller pair is running, the lead pair will be decreased to 50% load. The lead chiller pair is staged down when all chillers have been operating at less that 45%. The pump speed is determined by differential pressure sensors that read the pressure drop across the system. When the pressure drops below the set point, the pump speed is increased. The minimum and maximum flow rates are set to chiller requirements provided by the manufacturer.

Alarms are sent to the BAS when temperature varies from the set point by 5 F for more than five minutes and when any time pressure drops by more than 2 psi. In the later case, the entire system will shut down since this generally symbolizes a leak.

7.2.2. Condenser Water

7.2.2.1. System Schematic

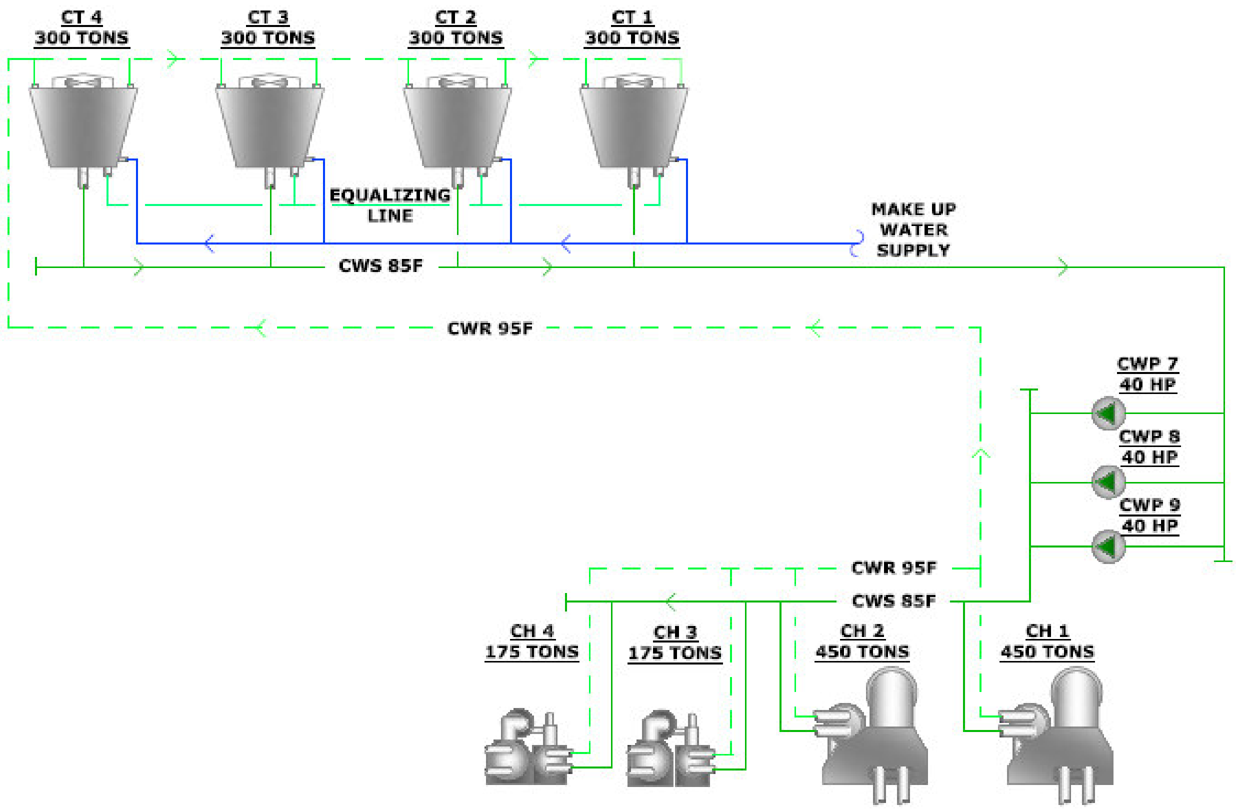


Figure 7-5 Condenser Water Schematic

7.2.2.2. System Operation

Chiller plant heat rejection is provided by four 300 ton open cell cooling towers. Condenser water is pumped from the chiller plant to the cooling towers by three variable speed drive condenser water pumps (CWP 7, 8, and 9). As illustrated in figure 7-5 make up water is supplied to the basin of each cooling tower. Additionally electric heating is provided to each tower to prevent water from freezing in the winter.

The condenser water system is operated in response to the chilled water system. Two sets of two cooling towers and one condenser water pump are work in lead/lag mode. Run times are logged to determine the lead/lag positions. If load requires, as determined by the basin temperature, cooling towers are stepped up from 50% to

100%. If the basin temperature continues to rise, the next cooling tower will be staged on with its respective pumps. Both temperature and level sensors are provided in the basin of each tower. When the water level falls below the set point, make up water is supplied to the system. If the temperature falls below the set point, electric heating is provided to prevent freezing.

7.2.3. Steam & Hot Water Systems

7.2.3.1. System Schematic

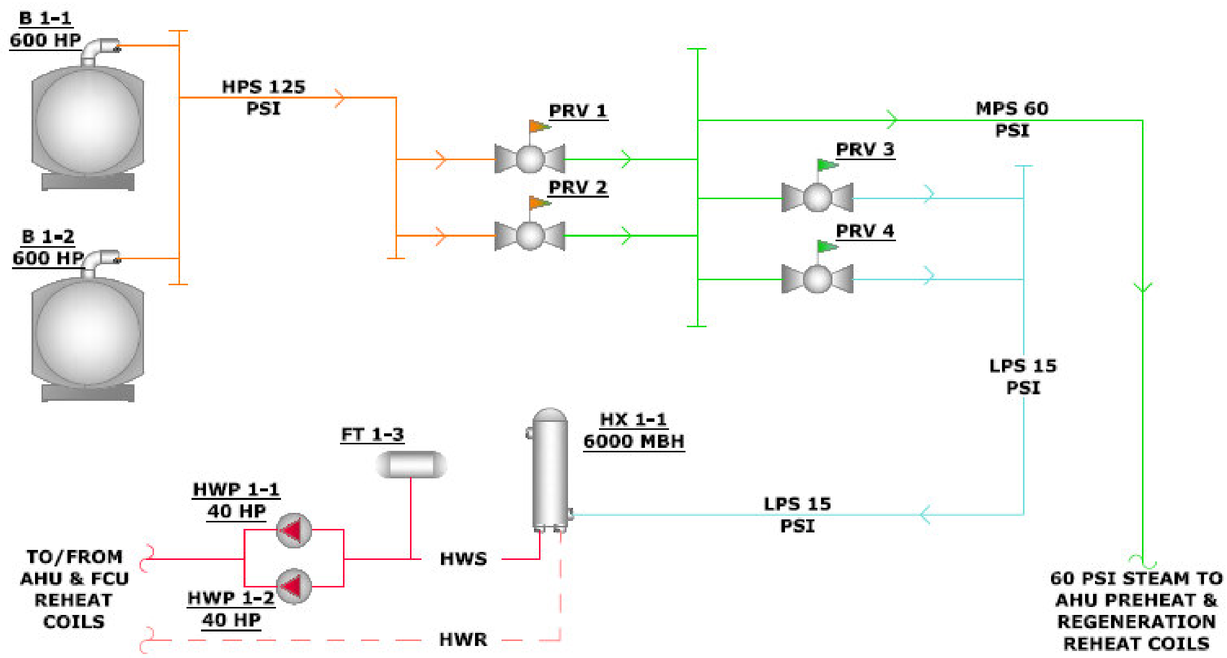


Figure 7-6 Steam and Hot Water Schematic

7.2.3.2. System Operation

The heating process begins with two 600 HP boilers that produce 125 psi steam. The steam is sent through pressure reducing valves as shown in figure 7-6 and is sent to the system at both 60 psi and 15 psi steam. The medium, 60 psi steam is distributed to the preheat, reheat, and reactivation coils of the the desiccant AHU's while the low, 15 psi steam is sent to the shell and tube heat exchanger to heat the hot water. Hot water is then used in the preheat coils for the VAV air handling units.

The boilers operate on a lead/lag configuration which is determined by run time. Differential pressure sensors measure pressure drop across the system to determine the required boiler load. When the boiler is required, the DDC will open the isolation valves and start the lead boiler. When the pressure drop across the system exceeds a certain set point, the lag boiler will be started. When both boilers are in operation, the firing will be matched. Load is decreased on the boilers as the coil valves close and pressure drop increases. If the load on both boilers drops below 45% the lead boiler will be shut down. Emergency shut down buttons will be located outside the mechanical room so entrance is not necessary.

The 6000 MBH shell and tube heat exchanger provides hot water to the AHU and FCU reheat coils. The hot water is distributed by two variable speed drive 40 HP pumps. By monitoring the pressure drop across the system, the DDC will ramp the active pump up or down to adjust the load on the heat exchanger. The remaining pump is available as a stand by to be started when the primary pump fails.

8. REFERENCES

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